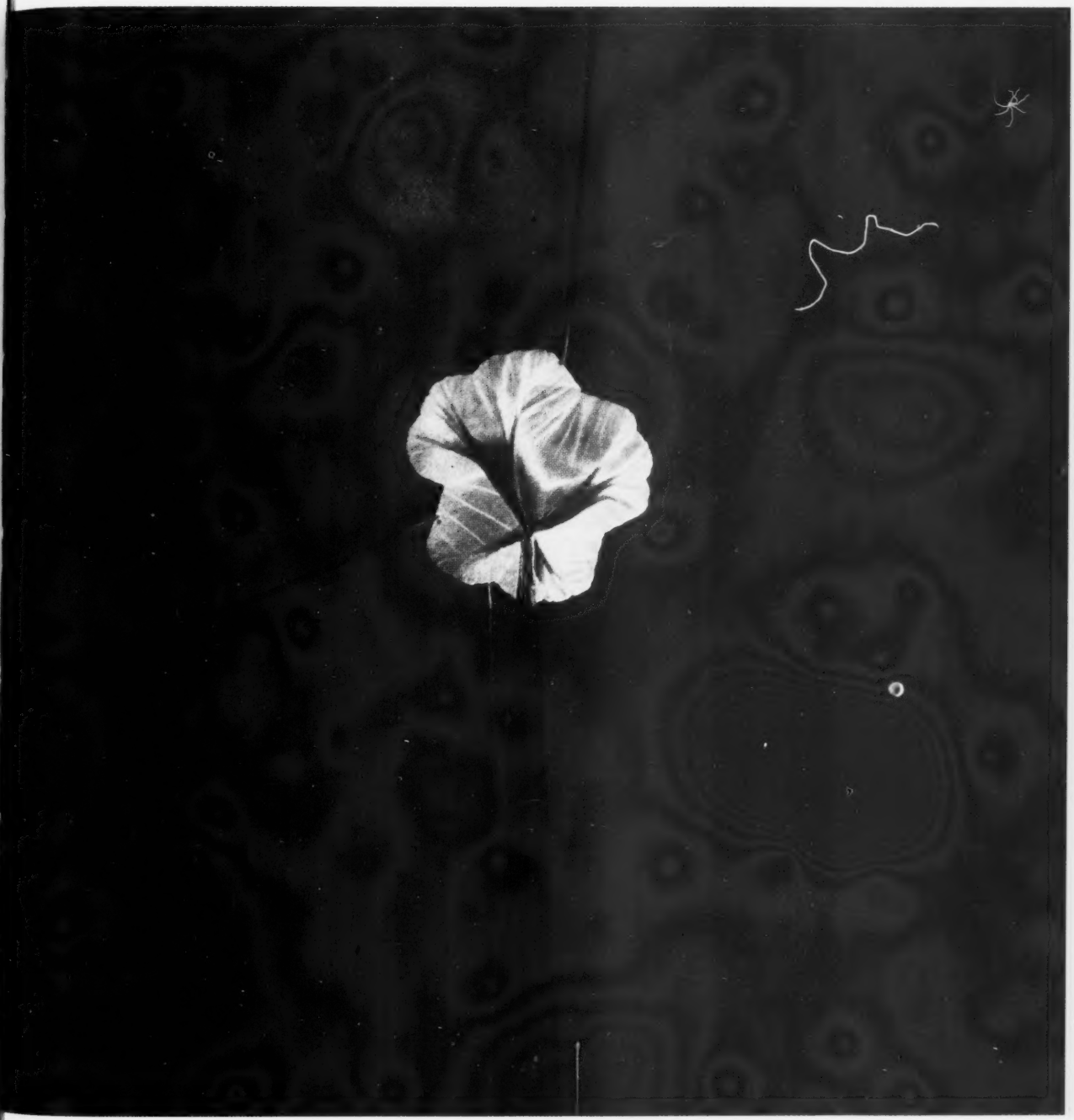
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

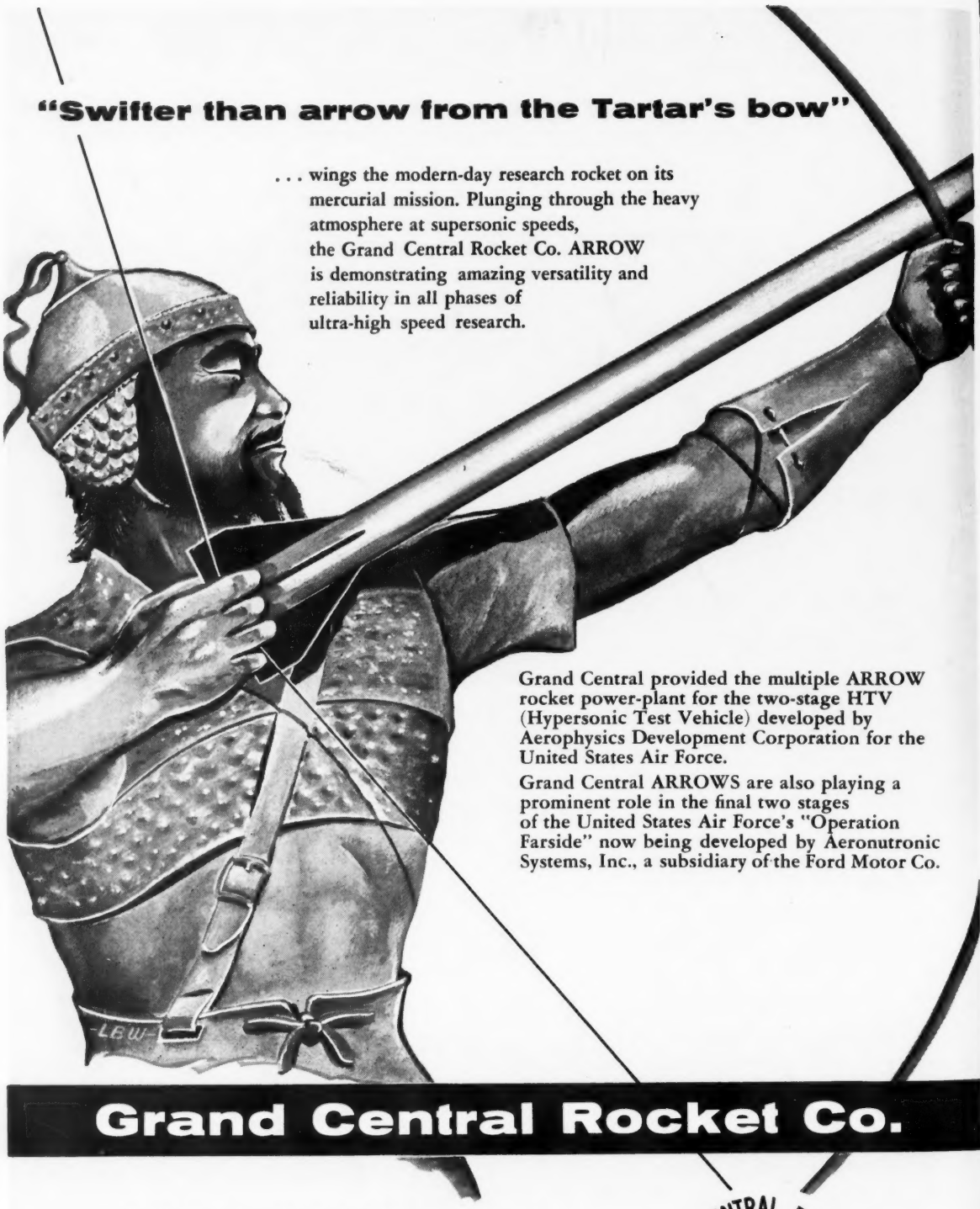
NOVEMBER 1957



SPECIAL REPORT ON RED SATELLITE

The Anthropology of Astronautics.....*Krafft A. Ehricke*

Weightlessness.....*Siegfried J. Gerathewohl*



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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC

November 1957 *volume 2 number 4*

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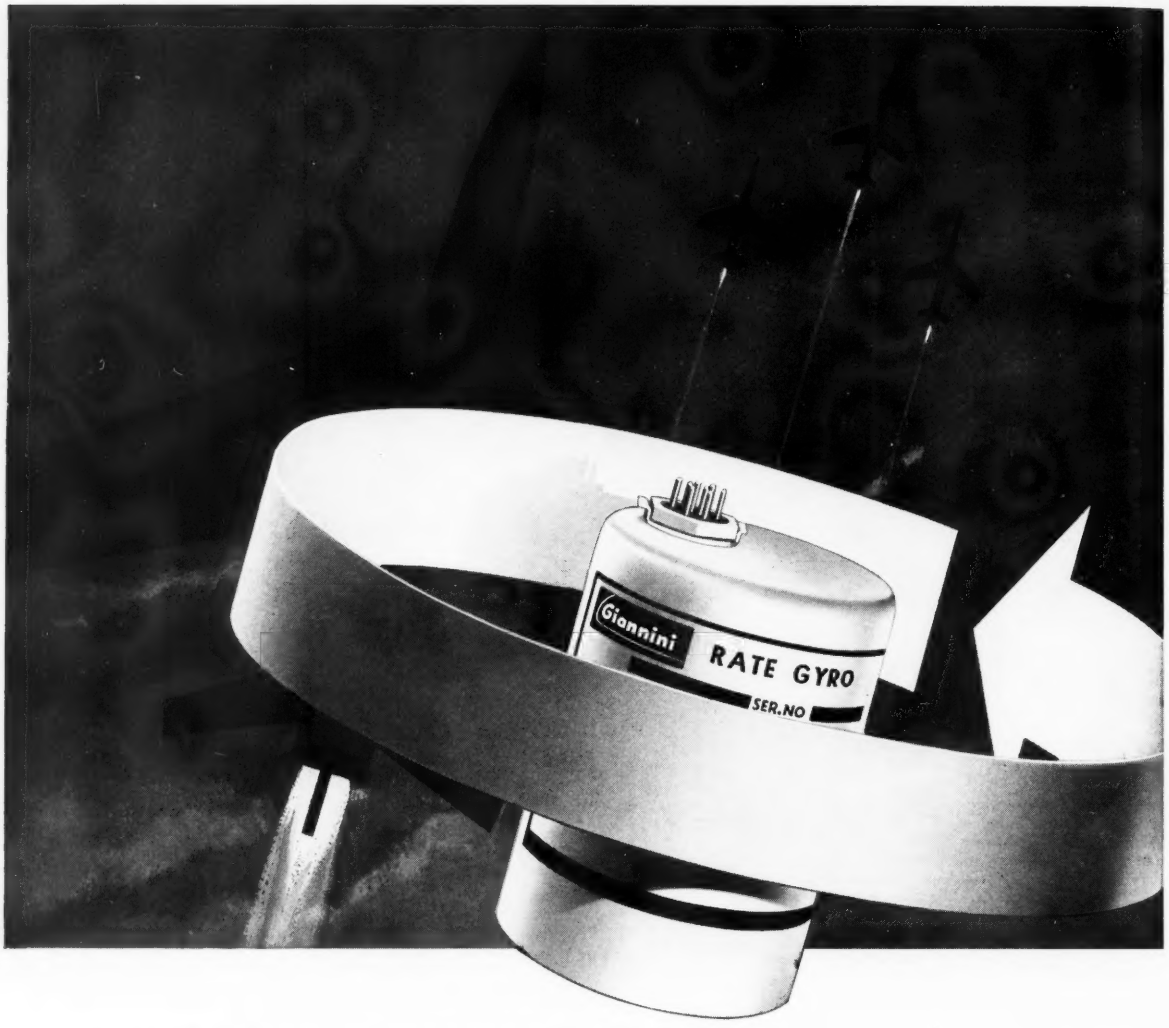

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at press time

Up-to-the-minute news about the rocket, guided missile and jet propulsion fields

ROCKET PROJECTS

• Project Far Side, which was officially scheduled to take place during the latter part of September, apparently got snagged on the coral reefs of Eniwetok Atoll. Present indications are that the first shots were not successful. The Air Force, which has but a limited number of birds for the project, says that it will wait until it has results from a successful shoot before making a statement.

It was hoped that this balloon-launched research rocket, which was designed to go 4000 miles up into the atmosphere, would snare some headline space from the Russian satellite. New Far Side firings were due momentarily as this issue went to press.

• A top Navy spokesman reveals that the Polaris IRBM program has hurdled most of the big technical barriers and is ahead of schedule. Milestones:

The problem of obtaining accurate cutoff has been licked, says the Navy. A stable grain solid propellant has been developed, and cutoff is now claimed to be 10 times more accurate than with lpr engines.

The problem of pinpointing exact fix of seagoing launch sites (in order to determine accurate trajectory) is also a thing of the past. Results from the first runs of the experimental seagoing launching platform, the *USS Compass Island*, are now in, and indicate accuracy to within $^1/_4$ mile.

Most of the problems attendant upon underwater firings have also been solved, and the Navy is now confident that Polaris can be fired from a submerged submarine.

(The missile itself has not been fired, despite reports to this effect by one trade magazine.)

POWER PLANTS

• Ionic power plants almost seem assured of a place in the propulsion spectrum of the near future. Both NACA and AFOSR believe a practical motor will evolve from present studies in this field.

The two most promising possibilities are the ion rocket and the ramjet. The rocket would carry its own fuel, such as cesium, and its own means of converting the fuel into positive and negative ions through the use of nuclear or electromagnetic energy. Principal market for the rocket would be in interplanetary flight. It would, of course, have to be pushed beyond the earth's atmosphere by more conventional means. This is essentially the approach now being taken by Giannini, GE and others with the plasma jet and NACA with its ion gun.

The second approach, the ramjet, would carry only a catalyst and rely upon catalytic reformation of ions already present in the upper atmosphere, such as atomic oxygen. This, of course, would limit the operation of a vehicle to that area where free ions occur and suggests satellites with nonballistic or controllable trajectories, space stations, manned research-weather-television platforms and the like.

The second possibility is the one that definitely interests the Air Force Office of Scientific Research and the AF Cambridge Research Center. RPI's Dr. Paul Harteck is carrying out a thorough study in this area under the sponsorship of both groups. OSR's part of the study has been completed, is now in print and will be distributed to DOD contractors as soon as it comes off the press.

• Cause of the rocket motor explosion which killed Chance Vought representative Herbert Bell was traced to a pump in the lpr unit. Trouble occurred while motor was being moved to test stand at Lake Denmark, N. J. The stand itself was undamaged and the trouble has been corrected, reports Reaction Motors.

No delay is foreseen in the development program for the engine which,

reportedly, is designed as a supplemental power plant for the turbojet C-V Crusader.

• Main power plant of Lockheed's new Mach 2 target drone, the Q-5, is reported to be a Marquardt ramjet. The vehicle is approximately 39 ft long, has a wingspan of 10 ft and weighs over 7600 lbs. A rocket boosts the drone to ramjet operating speed.

COMPANIES

• You can expect to hear more of Stauffer Chemical's new process for making high energy fuel intermediates. Under development at the company's Richmond, Calif., research laboratories, the process may cut the cost of the chemical intermediates by as much as two-thirds. Charles Hunt is in charge of the program.

• Current reorganization at Reaction Motors is tied in with firm's new position in solid propellant field. Lpr-pioneer RMI now "officially" believes solids have a bright future and, together with Olin Mathieson (but without Marquardt), has set up an organization similar to OMAR to produce spr motors from grain to casing. Company reports it already has a number of R&D contracts in new line.

PEOPLE

• Andrew G. Haley, former president, present director and general counsel of the AMERICAN ROCKET SOCIETY, is the new president of the International Astronautical Federation. He succeeds Leslie R. Shepherd.

• Col. William O. Davis, AFOSR, has irritated Defense Dept. with his unbridled advocacy of space flight, causing embarrassment of top AF brass. This is said to be real reason for Davis' "routine" transfer to Wright Field administrative post. "And the prophets must be stoned," one insider cynically remarked.

MEETINGS

• Those who have not yet received an invitation to attend the Los Angeles symposium on Advanced Propulsion Systems should contact George Sutton of Rocketdyne. The meeting is jointly sponsored by Rocketdyne and AFOSR's Directorate of Advanced Studies and is classified. Dates: Dec. 11–13.

• Third Monopropellant Symposium, which took place Oct. 29–30 in New York City, had all the earmarks of a wide-screen spy thriller. FBI spent days checking windows, entrances, exits, etc., of N. Y. Athletic Club to make sure there would be no unauthorized, unobserved eavesdroppers at classified gathering. Host Stauffer Chemical refused to admit existence of meeting until after it had taken place.

Purpose of the meeting was to review and advance information that might lead to development of new, higher energy liquid monopropellants. Sixty top men in liquid propellant field from industry and government attended. Sessions covered new HE chemicals test methods, applications, ignition and combustion. Capt. H. L. Leon, executive director of BuAir's R&D Division, was the featured banquet speaker.

IGY

• Satellite Sidelights: A little over two years ago, when the government's guided missile policy committee decided against the Von Braun-Medaris satellite proposal in favor of Project Vanguard, there were four dissenters who voted to send the idea on to the National Security Council for further consideration. One of them was the "Lone Eagle," Charles A. Lindbergh, the last one to make aviation headlines of the same magnitude as "Sputnik."

• Soviet scientist A. A. Blagonravov says Russia will launch a second satellite in a month or so and that it will be "two or three times" as heavy as the first one.

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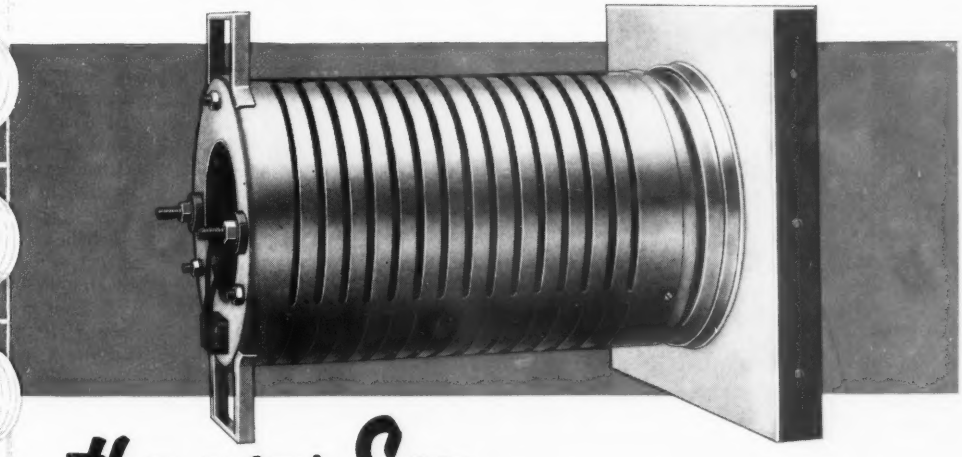

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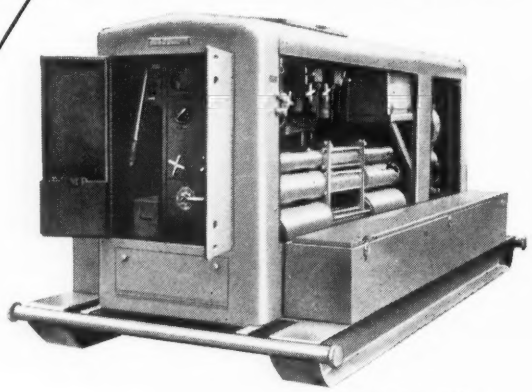

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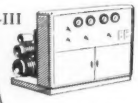
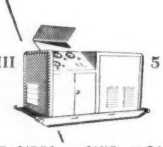
MODEL LS-III 40 TO 80 SCFM



FOR TEST SITES — STATIONARY

MODEL SM-III 5 TO 30 SCFM



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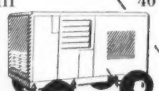

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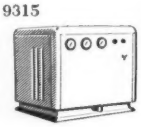

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feedback

First Propulsion Center

Dear Sirs:

I read with much interest the article entitled "When Will Rockets Go Commercial?" by G. Edward Pendray in the September ASTRONAUTICS.

However, I must take issue concerning the remarks made in the second paragraph of the article, which state that Princeton University and California Institute of Technology are the first centers of graduate education and research in rockets and jet propulsion in this country.

I believe this statement to be incorrect, since graduate instruction and research in the aforementioned fields have been given at Purdue University since 1946. I might also point out that the first undergraduate course in jet propulsion at Purdue University was also given in September of 1946.

M. J. ZUCROW
Professor of Gas Turbines
and Jet Propulsion
Purdue University
Lafayette, Ind.

No Newsstand Sales

Dear Sirs:

I own a newsstand and would like to know if I could make arrangements to carry a few copies of ASTRONAUTICS. I have a number of customers who are interested in this type of literature. We also have an Astronautical Society here in Fort Lauderdale.

RUTH P. LITTLE
Little's International Newsstand
250 S. E. Second Ave.
Fort Lauderdale, Fla.

Several queries have been received concerning newsstand sales of ASTRONAUTICS. *Such sales have never been contemplated, since the magazine is an official* AMERICAN ROCKET SOCIETY *publication, and is not intended for the lay reader. While individual subscriptions may be purchased by people who are not ARS members, the magazine is directed specifically at scientists and engineers actively engaged in rocketry and allied fields—Editor.*

Why Volume 2?

Gentlemen:

We have a subscription to ASTRONAUTICS and have received Volume 2, Numbers 1 and 2, dated August and September, 1957, respectively.

However, we are unable to determine just what Volume 1 consists of.

(CONTINUED ON PAGE 61)

How to judge a new brand of magnetic tape

"Ampex Instrumentation Tape" bows in with facts and figures

Whether you are a believer in heredity or environment, here is a mighty offspring to watch. Ampex Instrumentation Tape shares a distinguished family name with Ampex's Tape Recorders. It inherits a wealth of experience. It is growing in a fertile environment of research, testing, and process improvement.

For many years each new Ampex Tape recorder has been a significant advancement in the state of the art. But in making these forward steps, Ampex's engineers repeatedly have come face to face with need for improvements in tape as well. Ampex is now sharing research and knowledge with Orradio Industries to set new standard in tape excellence. Orradio is originator of the Ferro-Sheen process – also is the largest manufacturer dedicated exclusively to magnetic tapes.

PREMIUM QUALITY FOR SLIGHT EXTRA COST

Ampex Instrumentation Tape is a superior quality sold at slightly higher price than regular instrumentation grades. For this difference it offers a number of special advantages. Each individual reel is tested for freedom from dropouts. Uniformity from reel to reel is maintained to ±0.5 db. Within the reel, it is ±0.25 db. All the types we offer are compatible to each other and require no special bias settings. These are specifications we invite you to test for yourself.

Ampex tape can soon be ordered with precision reels. These greatly improve tape guidance and provide uniform, distortion-free tape wrap. A center plastic strip grips the tape to start.

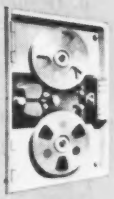
TWO QUALITIES YOU CAN EASILY TEST

An oxide surface of exceptional smoothness distinguishes Ampex Instrumentation Tape from others. It is achieved by the Ferro-Sheen process. There are no small surface projections to rub off and accumulate oxide on heads and guides. The microscopic flatness also achieves better tape-to-head contact eliminating "noisy" variations in signal strength. Also, Ampex tape is made with a binder of exceptional adhesive strength. Try to strip the oxide off a sample of Ampex tape. Then compare it with others.

The completeness and accuracy of specifications that have always distinguished Ampex recorders are extended to magnetic tape too. The new Ampex magnetic-tape brochure clearly differentiates the kinds of tapes we offer and gives relevant specifications, features and tape-testing techniques. May we send you a copy?

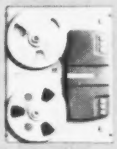
MAGNETIC TAPE APPLICATION BY AMPEX

ONE OF A SERIES

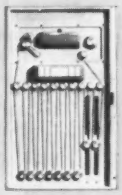


Series FR-100

Series 800 Mobile and Airborne



Model FR-200 Digital



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people in the news

APPOINTMENTS

Brig. Gen. Stanley T. Wray (USAF) has succeeded **Maj. Gen. Thomas L. Bryan Jr.** as commander of ARDC's Wright Air Development Center, Wright-Patterson AFB, Ohio. Gen. Bryan recently underwent major surgery and is expected to have a long convalescence prior to returning to full duty. Gen. Wray was formerly chief of the Electronics Defense Systems Div. of AMC's Directorate of Procurement and Production.

J. F. Harrigan has been appointed manager of the Dayton, Ohio, liaison office jointly maintained by Reaction Motors, Inc. and Olin Mathieson Chemical Corp. He was formerly with Lear, Inc.

Harrigan

Place

Douglas C. Vest, formerly in charge of applied interior ballistic research, Aberdeen Proving Ground, has been named director of research and development at Redel Inc.

National Science Foundation has named **William E. Benson,** program director for earth sciences, Div. of Mathematical, Physical, and Engineering Sciences, and **Grant W. Smith,** program director for summer institutes, Div. of Scientific Personnel and Education.

E. William Place, former product manager for missile devices, has been appointed manager of the new Missile Products Div. of Beckman & Whitley, Inc. **John C. Beckman,** co-founder of the firm, will be general manager of the new Instrument Div.

Six new directors have been named by Haydu Electronic Products. They are **Col. Jack B. Dunn, Leo C. Beebe, Edward A. Conti, Roe Nardone, Robert K. Berry** and **Arthur E. Wastie.**

Antonio Ferri has been named head of the aeronautical engineering department of the Polytechnic Institute of Brooklyn. Dr. Ferri came to the school in 1951 to found a special aerodynamics laboratory, where he is now actively engaged in research work connected with the ICBM and other long-range missiles, design of ultra-high-speed aircraft and astronautical problems.

John A. Hewlett, formerly with Fairchild Camera & Instrument Corp., has been named treasurer, and **Thomas N. Hamilton** has been elected a vice-president and secretary of Cohu Electronics.

Frederick C. Durant III has been named executive assistant to the director of the AVCO Research Laboratory, Everett, Mass. A former president of the AMERICAN ROCKET SOCIETY and president of the International Astronautical Federation from 1953 to 1956, he has been with Arthur D. Little, Inc., since 1954 and prior to that was with Bell Aircraft Corp. and the Naval Air Rocket Test Station.

Three Clevite Corp. executives have been appointed division heads in a realignment of the company's electronics activities. **Curtis B. Hoffman** becomes general manager of the newly formed Brush Instruments Div.; **James D. Lightbody,** general manager of the new Electronic Components Div.; and **Thomas E. Lynch** general manager of the new Ordnance Div.

Donald K. Coles has been appointed head of the Farnsworth Electronics Co. solid state laboratory. For the past 15 years, Dr. Coles was with Westinghouse Research Laboratories, where he worked on applications of solid state physics to industrial products.

Durant

Rockwell

Charles S. Rockwell, formerly vice-president and general manager, Ford Instrument Co. Div. of Sperry Rand Corp., was named president and general manager last month upon the retirement of **Raymond F. Jahn.** Rockwell has been associated with the corporation since 1943.

PacAero Engineering Corp. has elected **Robert A. Hall** a vice-president and member of the board. Formerly chief of missile manufacturing for Northrop Aircraft, Hall has been test and ground support equipment division manager at the company's main plant in Burbank for the past year.

William C. Stolp has been promoted to assistant service manager of the Chandler-Evans Div., Pratt & Whitney Co., Inc., responsible for internal technical operations.

Roy E. Wendahl has been named to the new post of vice-president of sales, Hughes Aircraft Co. He was formerly a vice-president and manager of Tucson operations for the company.

Wendahl

Gaither

Loren E. Gaither has been appointed director of communications engineering for Philco Corp.'s Government and Industrial Div. Col. Gaither, who retired from the Army Signal Corps in 1955, was formerly director of government and industrial engineering for Magnavox Co.

Robert K. Maddock will head the newly formed Research and Development Engineering Dept. in Fruehauf Trailer Company's Missile Products Div. The department has been set up to handle steadily increasing government contract work.

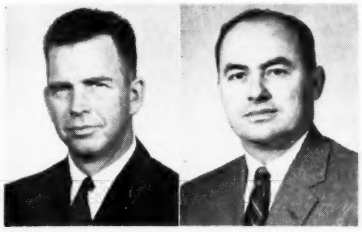
L. P. Nelson has been advanced from acting manager of transportation, Olin Mathieson Chemical Corp., to director. He also was director of traffic for the corporation's Blockson Chemical Div.

Kenneth M. Kiel has been appointed to the new post of new product development manager, Defense Sales Div., Burroughs Corp. He formerly served as director of administration, research and engineering, and as technical coordinator, product planning.

Paul J. Meeks, vice-president, Clary Corp., has been named general manager of Clary Dynamics, a new unit comprised of the company's Aircraft and Automatic Controls Divs., which will develop and manufacture aircraft and guided missile components. **Brian**

Sparks will be assistant general manager.

Bernard Greifer joins the Kinetics and Combustion Group, Atlantic Research Corp., where he will conduct fundamental and applied research in gaseous and solid combustion processes. Dr. Greifer was formerly a member of the Pittsburgh Physical Research Section, U. S. Bureau of Mines.



Noll **Davis**

W. T. (Ted) Noll has been named manager of production, personnel and procurement, and **C. L. (Chick) Davis** has been appointed manager of sales, planning and research in the Aeronautical Div. of Minneapolis-Honeywell Regulator Co.

Samuel Bousky has been named director of engineering of Chicago Aerial Industries, Inc. The company's engineering, research and systems development departments will be combined into a unified technical organization under Bousky.

William E. Grago Jr., chief pilot, has been transferred to Rheem Manufacturing Co.'s Aircraft Div. from the Philadelphia plant where he was active in the development of the F-100 flight simulator. He will participate in military relations and act as chief pilot in the operational development of the surveillance drone program. **Clifford A. Busse,** former assistant manager and chief engineer, missile test equipment, Farnsworth Electronics Co. comes to Rheem as engineering manager, Electronics Div.

William C. Norris, former vice-president and general manager, Remington Rand Univac Div., has been elected president of the new research firm, Control Data Corp., Minneapolis. Other officers are **Arnold J. Ryden,** vice-president, secretary and treasurer; **Frank C. Mullaney** and **Willis K. Drake,** directors of engineering and marketing, respectively. Both Mullaney and Drake were with Remington Rand Univac as director of military systems engineering and assistant to the general sales manager, respectively.

HONORS

Maj. Gen. John B. Medaris, Commanding General, Army Ballistic Missile Agency, Huntsville, Ala., recently presented the Agency's Merit Certificate to **R. W. Cuthill,** deputy director of industrial operations, for his outstanding service in organizing the industrial activity at ABMA.

Robert J. Jeffries has been elected president of the Instrument Society of America for the coming year. He is assistant to the president of Daystrom, Inc., and founder and director of Educational and Technical Consultants, Inc.

Charles E. Taylor of Northrop Aircraft Corp. has been elected president of the Society of Photographic Instrumentation Engineers.

Capt. Grayson Merrill (USN Ret.), director of engineering, Fairchild Guided Missiles Div., was recently awarded the Legion of Merit by Rear Adm. W. F. Raburn, director, Special Projects Office, BuOrd, for his outstanding services to the government from 1942 to 1953. He was cited for his "excellent judgment and leadership in the development of guided missiles," and for his part in the establishment of the U. S. Naval Air Missile Test Center.

on the calendar

Nov. 1	Third Annual Technical Meeting, IRE Professional Group on Electron Devices, Shoreham Hotel, Washington, D. C.
Nov. 3–8	Second International Conference, Society for Nondestructive Testing, Hotel Morrison, Chicago, Ill.
Nov. 6–8	Fuels and Lubricants Meeting, SAE, Cleveland, Ohio.
Nov. 11–13	Instrumentation Conference and Exhibit, IRE, Atlanta, Ga.
Nov. 25–26	Joint Meeting, IAS and Canadian Aeronautical Institute, Montreal, Quebec, Can.
Dec. 1–6	Annual Meeting, ASME, New York, N. Y.
Dec. 2–5	**American Rocket Society 12th Annual Meeting, Hotel Statler, New York, N. Y.**
Dec. 3–4	Joint Symposium, IRE and Human Factors Society of America, Penn-Sherwood Hotel, Philadelphia, Pa.
Dec. 6	**American Rocket Society Eastern Regional Student Conference, Hotel Statler, New York, N. Y.**
Dec. 8–11	Annual Meeting, AIChE, Chicago, Ill.
Dec. 17	Wright Brothers Lecture, IAS, Washington, D. C.
Dec. 17–19	Conference on Nuclear Sizes, American Physical Society on West Coast, Stanford University, Palo Alto, Calif.
Dec. 19–21	Winter Meeting, American Physical Society on West Coast, Stanford University, Palo Alto, Calif.
Dec. 26–31	Annual Meeting, American Assn. for the Advancement of Science, Indianapolis, Ind.
1958	
Feb. 4–6	Thirteenth Annual Technical and Management Conference, Reinforced Plastics Div., The Society of the Plastics Industry, Inc., Chicago, Ill.
March 16–21	1958 Nuclear Congress, Chicago, Ill.
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**
June 3–5	**National Telemetering Conference (under auspices of ARS, IAS, AIEE, ISA), Lord Baltimore Hotel, Baltimore, Md.**
June 9–11	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
June 19–21	**Heat Transfer and Fluid Mechanics Institute Meeting, University of California, Berkeley.**
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Dec. 1–5	**ARS 13th Annual Meeting, New York, N. Y. York, N. Y.**

Integration in Baltimore

Long talked about, the Air Force concept of integrated missile systems materialized only recently, in Baltimore, when Martin officially presented a complete Matador system to an AF engineering inspection team.

Redesignated TM-76 instead of TM-61B, the system includes in addition to the missile, the launcher, prime mover, test equipment and ground handling equipment. Martin makes the missile but, as prime contractor, is responsible to the AF for all other items as well.

The system, now being checked out at Holloman, is scheduled for production early next year.

in print

Guided Weapons, by Eric Burgess, Macmillan, New York, 1957, 255 pp., illustrated. $5.

Reviewed by CAPT. GRAYSON MERRILL, USN (Ret.), Fairchild Guided Missiles Div.

In his preface Mr. Burgess states: "If this book encourages more students and newly qualified men to start thinking actively about guided weapons and their problems, if it enables the intelligent layman to appreciate why his taxes have not yet secured his cities beneath missile screens, it will have achieved the author's purpose." The reviewer believes he will surely attain the first but may miss the second by overstraining the technical vocabulary and training of the "layman."

"Guided Weapons" is remarkably compact and contains a useful reservoir of guided missile information. The first four chapters are entitled "Systems and Missiles," "Propulsion and Propellants," "Guidance and Control" and "Testing and Test Facilities." In these chapters, Mr. Burgess skillfully describes the major techniques and hardware which are employed in missile design and, to a lesser extent, tactical use.

No Mathematics Used

No mathematics are employed, but technical terms which may be unfamiliar to most students, and certainly to laymen, are liberally used. For example, one finds this typical passage under "Guidance and Control": "The other type of transistor is the junction transistor and this shows considerable improvement in its noise level. It can accordingly be used to amplify faint signals. It gives appreciable power gain without change in current because the emitter has high impedance while that of the collector is quite low."

This kind of material is intelligible and valuable to the advanced student or practicing engineer. These four technical chapters can therefore be favorably recommended to readers of ASTRONAUTICS. The technical coverage has been well-selected and lucidly and accurately set forth. The illustrations are simple but effective; photographs predominate. Rather extensive references are supplied, although most are British and therefore rather difficult to obtain.

Generally speaking, a person of substantial technical background who is curious about guided missile techniques or who may wish to broaden his knowledge thereof would be well advised to read the first four chapters.

Describes Current Missiles

The last four chapters, comprising about one-half of the 255-page book, classify and describe a large number of historical and some current guided missiles. At this point one might express sympathy to Mr. Burgess in his task.

Understandably, the release of technical and status information on specific guided missiles is severely circumscribed by security restrictions. Unhappily, information releases on a missile are often made coincident with a decision to "shelve" it. Therefore, our most accurate and voluminous information is on obsolete missiles.

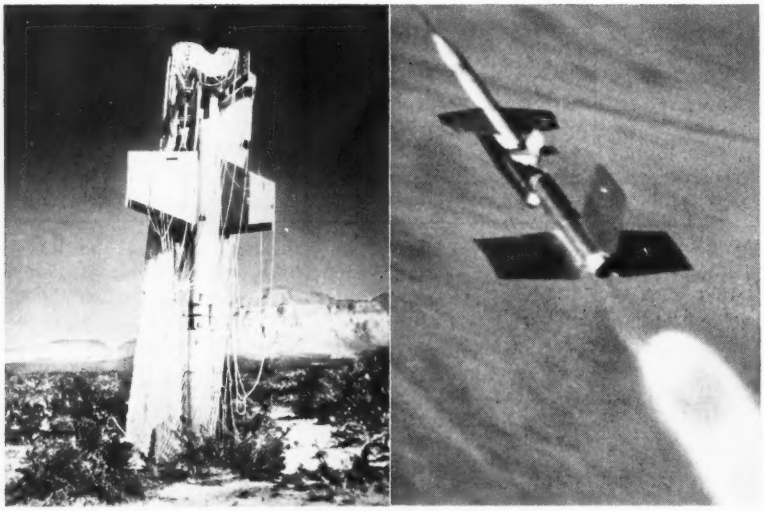
Lacking specific knowledge on current missiles, certain circulation-hungry periodicals deduce missile characteristics and ascribe progress to them which is at variance with the facts. Authenticity is implied by innuendo.

Soviet Data Questionable

The worst cases involve Soviet missiles, in which a gullible reader might conclude that the data were sent directly by the magazine's accredited Moscow agent. Unhappily too, such information gains credence by repeated printing and, in this case, appears in such statements as "Wasserfall production in Soviet hands has since equipped missile launching sites to screen Moscow, Leningrad and other defense areas." The reviewer, not being privy to foreign intelligence, will bet that if any missiles screen Moscow, they are of original Soviet design.

Other inaccuracies detract somewhat from the reference value of these descriptive chapters. As director of engineering of Fairchild's Guided Missiles Div., the reviewer is painfully aware that Lark is neither "used by

(CONTINUED ON PAGE 60)



X-7: With flight number 10, $3\frac{1}{2}$ million in the bank.

Bargain Missile

Somewhat like the wife who tells her husband that she saved him $10 by buying a $20 hat on sale for $10, Lockheed announces that its X-7 ramjet test vehicle is saving the taxpayer $350,000 every time it is fired, because the missile can be recovered and fired again.

Occasion for this announcement was the successful completion of flight number 10 by a X-7. Now being retired to pasture, this particular X-7 reportedly also chalked up records for "fastest speed for any ramjet-powered missile," "fastest speed for any ground controlled missile," and "fastest speed for any recoverable missile."

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capital wire

News highlights from Washington

MISSILES

• Successful launching of Red satellite focused attention on U. S. missile and satellite programs. While outgoing Secretary of Defense Charles E. Wilson discounted military significance of the satellite and said he had received no orders from the President to speed the programs, several members of Congress are clamoring for an investigation, while others are calling for establishment of a "Manhattan-type" project to superintend the over-all missile program.

• A decision between Jupiter and Thor has been delayed—maybe for quite a while. The idea of marrying the two weapons has been virtually abandoned, although any official announcement of the choice is likely to be a delicately-worded straddle. Odds favor ultimate selection of Thor, but Army may be permitted to carry Jupiter tests along temporarily.

• With budget problems pressing on every hand, rumors of Atlas-Titan merger are recurrent. But while officials admit this is a possibility at some future date, they discount talk that it could be forced soon.

LONG-RANGE RADAR

• AF Chief of Staff Gen. Thomas D. White caused a stir with his announcement of 3000-mile range radars soon to be operational. Speculation is that he was referring to radar developed recently by Columbia University. But, privately, Pentagon electronics experts challenged the inference that such a system was near operational status.

ANTI-MISSILES

• Both Army and AF are pressing toward anti-missile missile. There's general agreement that ICBM defense is feasible, but achieving it will require considerable time and be tremendously costly. Even then, 100 per cent defense could not be guaranteed. Administration is still undecided just how hard to push the project.

RUSSIA

• U. S. intelligence believes major Soviet missile test center is in Caspian Sea area, with long-range shoots being directed from there to Arctic regions. Soviet missile testing in the Far North is believed to be subsidiary, comparable to our own cold weather evaluations.

MONEY

• Authorization of $45,450,000 for NACA facilities and equipment to be used in hypersonic flight research, including missiles, was one of final actions by Congress before adjournment. While not an appropriation (NACA received $106 million in new money for fiscal 1958), effect of the action is to permit a start on facility expansion program.

• Assistant Defense Secretary W. J. McNeil partially lifted the secrecy shrouding ballistic missile spending statistics. Expenditures for ballistic missiles rose from "one-quarter of a billion dollars in fiscal 1956 to about one billion dollars in fiscal year 1957," he reported, adding that "for one ICBM wing the total initial capital outlay may reach one billion dollars."

Although the Administration continues to say that defense spending will be held to $38 billion in fiscal year 1958, knowledgeable officials admit privately that there's little hope of staying within that ceiling. Despite slowdowns and cancellations, missile programs are generating a lot of the financial steam that can't be cut off.

INDUSTRY

• More than 50 industry representatives and Federal officials met in Washington to discuss launching a new association to represent missile and rocket industry. Kendall K. Hoyt, veteran aviation writer and publicist, chaired the meeting and is Acting Secretary of the group.

Proposed association name is AMRI—Association of Missile & Rocket Industries. Tentative outline of purposes included: Providing central source of study and information; public education and encouragement of students; assistance to amateur research; and arrangement of symposia at missile centers throughout the country.

Although over 30 industry companies were represented, a formal resolution to found AMRI was tabled pending further study.

NEWS

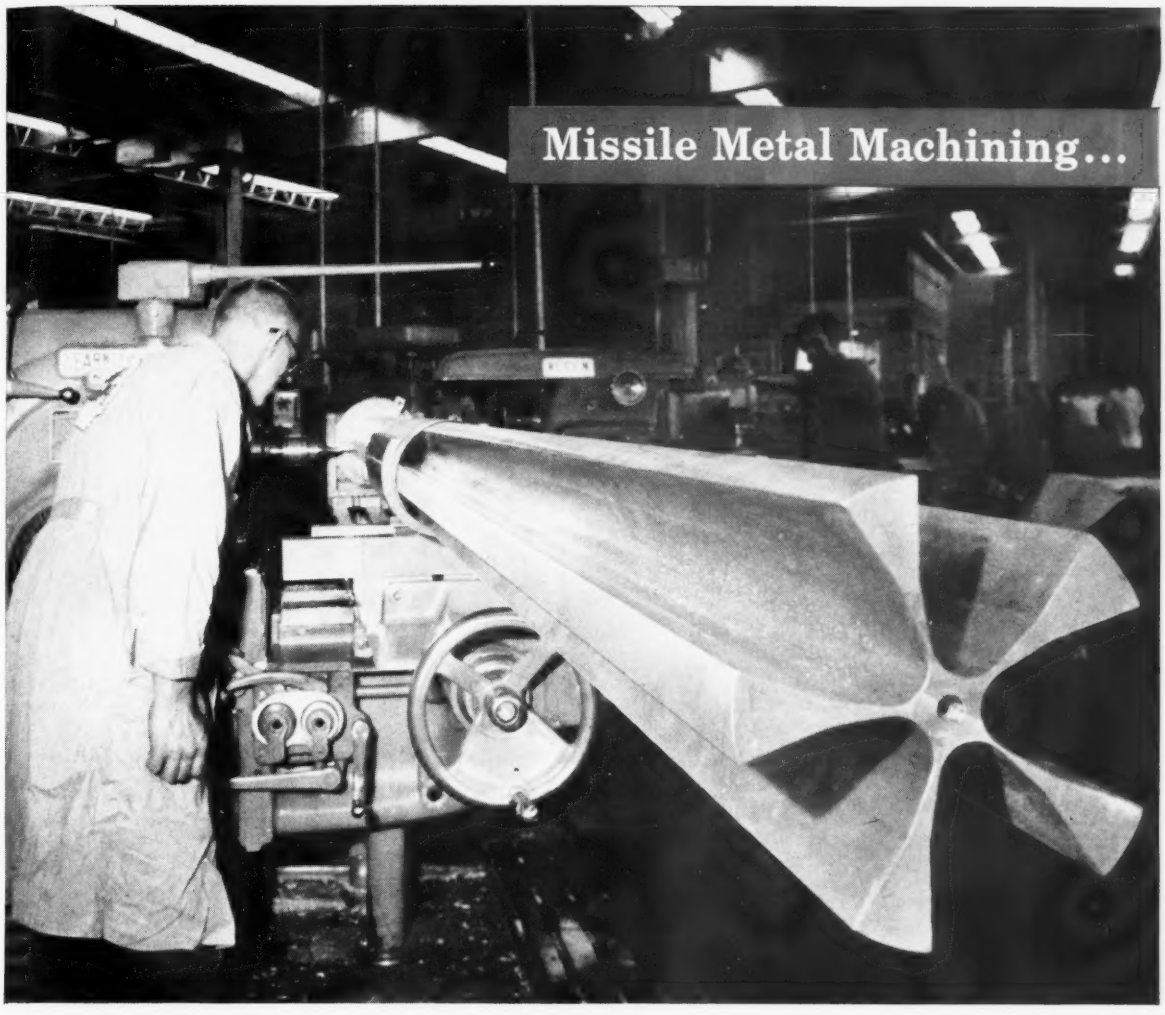
• The bitter Army-AF war over merits of Jupiter and Thor may have one fortunate result: A more realistic missile information policy. Top Defense officials, angered by row in which "leaks" have been the ultimate weapon, have drafted program calling for briefing correspondents on missiles and countering rumors and false claims by release of facts. It's before Operations Coordinating Board for approval.

Presidential O.K. will also be necessary, however, and plan could founder on Ike's reluctance to have U. S. talk about new weapons, even when experts give assurance that national security isn't involved.

A big reason for trying to hammer out new policy now is fear that the services may get involved in a controversy over anti-missile missile development that could dwarf current fracas.

RESEARCH

• A two-stage, gas-fired hypervelocity 40-mm gun designed to perform basic aeroballistic research on missiles was announced by the Naval Ordnance Laboratory. Made of standard gun steel alloy, the gun fires nylon-sphere test projectiles at over 18,000 fps, with temperatures in the chamber hitting 10,000 F. NOL is working on a 4-in. gun of similar design that will be an even better tool for aerodynamic research.



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COVER: *"Ecdysis of a Space Ship" is how that literate space surgeon, Col. Stapp, sees this early morning photo of Maj. Simons' balloon shedding its red plastic sheath (see page 30). Picture was taken by Mrs. Vera Winzen, vice-president of balloon-maker Winzen Research, Inc., prior to Simons' record-setting flight.*

Astronautics

NOVEMBER 1957

International Basketball

News of the successful launching by the U.S.S.R. of the first man-made satellite has been met in most responsible quarters with an attitude of scientific good sportsmanship. Certainly no one who espouses the cause of space flight can deny the magnitude of the feat nor hesitate in offering congratulations for what can only be regarded as an achievement of which mankind as a whole may well be proud.

While we in the United States should not panic at the thought of Russian success, neither should we be complacent about the implications of the feat. The first score by the Russians in the international technological basketball game clearly gives them an early lead in the contest for mastery of space.

While the Russians may be scientific good fellows, their politics are another matter. They must not be allowed to win this game—a game with far-reaching political, social and economic consequences.

The early lead gained by Russia thus far in the game, and its stated intention of widening this lead by rapid expansion of such probing to include even more spectacular endeavors in the field of space flight, should certainly prod us into a thorough examination of our own limited and short-term program.

The partial measures, hit-or-miss planning and confused organization that have marked our own work in this field to date are not likely to permit us to eliminate or even cut into the lead Russia has built.

Unless we as a nation recognize that astronautics will be to the last half of the present century what aeronautics was to the first half, and unless our space flight activities are organized so as to adequately exploit its potential over the long haul, the gap between our present position and that of the Soviet Union, still relatively small, will widen, rather than close—with results that could ultimately be disastrous.

ASTRONAUTICS Report—Part One

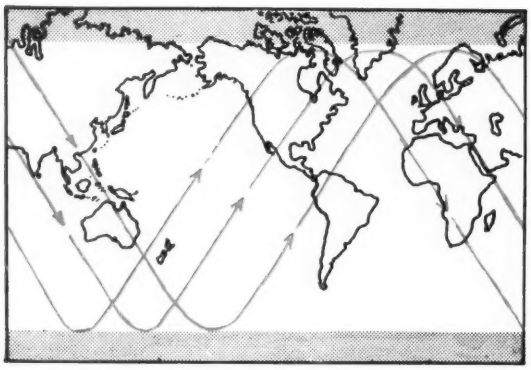
Problems of launching an earth satellite

This careful examination of the technical considerations inherent in any such project reveals the magnitude of the engineering feat accomplished by the Russians in the successful "Sputnik" launching

By Martin Summerfield

TECHNICAL EDITOR, ASTRONAUTICS

PROFESSOR OF JET PROPULSION, PRINCETON UNIVERSITY



Typical crossings of Russian "Sputnik" over the earth's surface.

Possible satellite launching range in the U.S.S.R.

THE SUCCESS of the Russian "Sputnik" was convincing and dramatic proof to people around the world of the real prospects of space travel in the not distant future. The fact that a 23-in. sphere weighing 184 lb has been placed in an almost precise circular orbit indicates that a number of important technological problems such as high thrust rocket engines, lightweight missile structures, accurate guidance, stable autopilot control, and large scale launching methods have been solved, at least to the degree required for a satellite project. To properly appreciate the nature of the achievement, it is necessary to examine the engineering aspects of the job of launching an earth satellite. This is the purpose of the present brief article.

This article does not deal directly with either the Sputnik or Vanguard projects, since very few facts have been released by the Russians about the first one, and only partial information is publicly available about the second. Rather, certain technical considerations are analyzed that are inherent in any satellite project.

Historical Perspective

The theoretical possibility of launching an earth satellite by multistage rocket, or even an earth-escape vehicle, has been understood for more than 50 years. In 1903, a monograph entitled "Rockets in Cosmic Space" was published in Russia by K. E. Ziolkowsky, in which the combustion temperatures and exhaust velocities of several possible rocket propellants were calculated, together with the flight performance of a rocket vehicle. It was concluded that extra-terrestrial flight could be achieved, particularly if a high-energy propellant such as hydrogen-oxygen were employed. Sixteen years later,

in 1919, R. H. Goddard pointed out in a Smithsonian Institution publication that multistaging would make it possible to land a visible payload of flash powder on the moon, even if solid propellant rockets of only modest performance were used. H. Oberth in Germany wrote a technical book on "Methods of Space Travel" (3rd edition, 1929) in which rocket motor performance was calculated and various flight programs were analyzed; one of the proposed flight programs was an earth satellite.

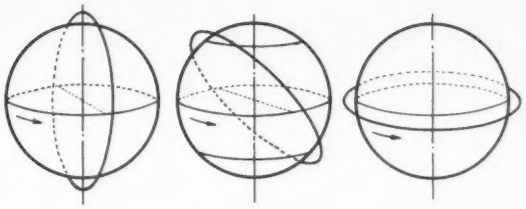
Since 1925, many technical papers, and popular ones as well, have been published on the subject. The main ideas that emerged from these early writings were: (1) The need for high jet exhaust velocity; (2) the importance of high full-to-empty mass ratio of the rocket vehicle; (3) the advantage of multistaging.

World War II brought about tremendous advances in rocket missile technology. At the end of the war, it was evident that Germany was very much in the lead, largely because it had started its program of rocket missile development as early as 1932 and had pushed it vigorously in the prewar period. Scientists in other countries (U.S.A., U. K., U.S.S.R., Japan, etc.) had, in the meantime, developed rocket devices for assisted take-off of aircraft, for anti-aircraft projectiles, for ship-to-shore barrage missiles, etc., and had also achieved an advanced level of rocket knowledge and know-how.

Technique Held Available in 1947

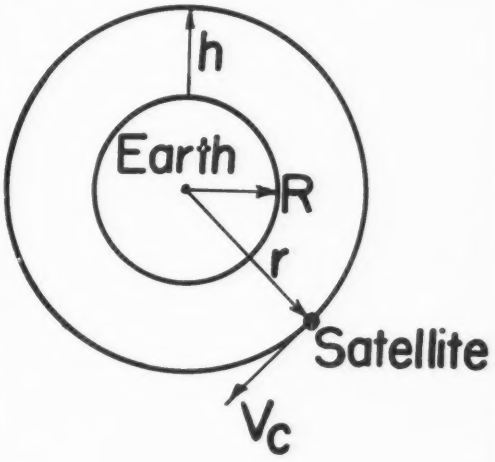
A re-examination of the technical feasibility of space flight was made in 1947 by the present writer and his colleagues (with Malina in the *Journal of the Aeronautical Sciences;* with Seifert and Mills in the *American Journal of Physics*), and it was concluded, on the basis of quite conservative design and performance factors, that "although many problems of navigation, flight control, instrumentation, etc., remain to be investigated, the basic technique is available by which a body can be propelled with the necessary velocity to escape from the earth."

In the years since 1945, the U. S. and the U.S.S.R. have invested large sums and great effort in advancing their respective science and know-how of rocket missiles, and in recent years the race for the development and production of long-range ballistic missiles brought forth large rocket engines, large rocket vehicles, accurate guidance systems, effective instrumentation, reliable telemetering devices, and well-equipped launching sites and firing ranges. All that remained was to apply this state of the rocket art to pushing an earth satellite into an orbit. The International Geophysical Year research program provided the excuse, the military services the means and the job was done. The Russians were



Satellite orbits: Left to right, circum-polar, inclined and equatorial.

Theory of the dynamics of circular satellite orbits.



Dynamic force balance:

$$\frac{m_s V_c^2}{r} = \frac{m_s g_R R^2}{r^2}$$

Orbital velocity:

$$V_c = \frac{(g_R R)^{1/2}}{\left(1 + \frac{h}{R}\right)^{1/2}}$$

Period of rotation:

$$T_c = \frac{2\pi r}{V_c} = 2\pi \left(\frac{R}{g_R}\right)^{1/2} \left(1 + \frac{h}{R}\right)^{3/2}$$

Energy required for circular orbit:

$$E_c = KE + PE = \frac{1}{2} g_R R \left(1 + \frac{h}{R + h}\right)$$

Energy required for complete escape:

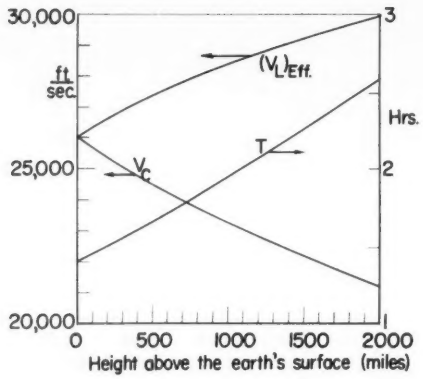
$$E_\infty = g_R R$$

Energy required for close-in orbit:

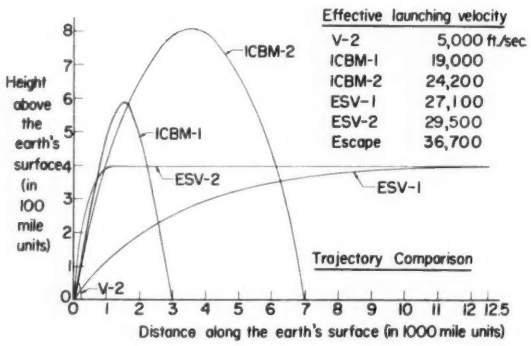
$$E_0 = \frac{1}{2} g_R R$$

Required effective launching velocity:

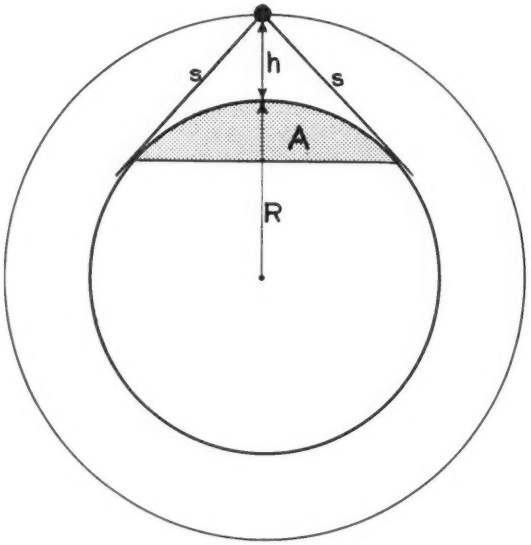
$$\frac{1}{2} V_L^2 \approx E_c$$



Characteristics of circular satellite orbits.



A comparison of several missile and satellite projects.



Region of the earth's surface observable from a satellite.

first on Oct. 4; the U. S., the President announced last month, will fire a small-scale satellite in December, a full-scale one in March.

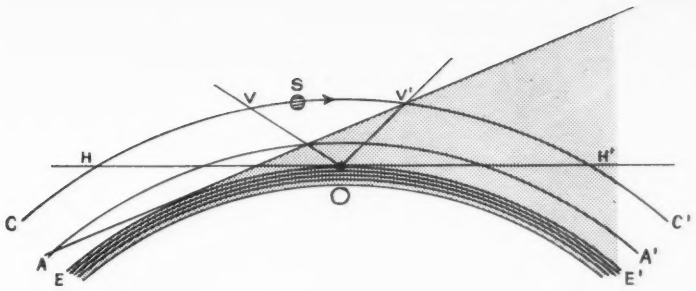
Orbit Selection

One of the first technical problems to be considered in planning an earth satellite project is that of orbit selection. How should the orbit be oriented with respect to the polar axis? At what distance above the earth's surface should the path be located? Should it be a circle or a fairly eccentric ellipse?

At the outset, we observe that the satellite travels in the centrally-directed force field of the earth, so that its orbit must lie in a plane passing through the center of the earth, as shown on page 19. Therefore, the orbital path must be a "great circle" or, more generally, a "great ellipse." The orbital path can follow approximately the longitudinal lines of the earth but not the latitudes. Inasmuch as the orbital period is much shorter than that of the earth's rotation, the path described on the earth will not retrace itself in successive revolutions but will look like a spiral inscribed on a sphere, and so even a circum-polar path will not lie exactly on a meridian. This is shown on page 18. There is one exceptional case, that of an equatorial orbit. A satellite in an equatorial orbit will remain at all times above the equator.

The choice of orbital plane, whether it is to be circum-polar, equatorial or inclined at some angle, depends on a number of considerations. Perhaps the most important is the available direction of the firing range with its associated tracking and telemetering stations. Such installations are relatively expensive to construct and require large staffs to operate, and so far have been established only for ballistic missile testing purposes, not for satellite launching. Long firing ranges for ballistic missiles have been developed in Australia pointing just west of north, in the U. S. from Cape Canaveral, Fla., toward the South Atlantic in a direction about 35 deg south of east, and presumably in the U.S.S.R. pointing northeastward about 50 deg from the Caspian Sea, as shown on page 18.

Another consideration is the "slingshot" increment of velocity that can be obtained from the rotation of the earth. An eastward launch into an equatorial orbit would give the satellite a "free boost" of 1520 ft/sec, that is, about 5 per cent of the necessary effective launching velocity. A westward launch would result in a penalty of the same magnitude. The slingshot effect diminishes as the cosine of the angle of latitude at the launching site, and also as the cosine of the angle of the launching direction vector from the East. Thus, the slingshot contribu-



Visibility of a satellite illuminated by sunlight.

tion to a satellite launched at 40 deg latitude in a direction of 25 deg north of east would be reduced to 1050 ft/sec.

A circum-polar orbit has the advantage of covering the entire surface of the earth, making it possible to report scientific data from the polar regions. An equatorial orbit has the advantage of easier tracking or "acquisition" of the satellite, since the path around the earth is repeated continuously, but there might be considerable reluctance to establish permanent military and scientific posts in equatorial climates. An orbit inclined at about 60 deg would cover most of the scientifically advanced nations of the world, thus making it possible to obtain a maximum amount of independent measurements and interpretations. An inclined orbit is clearly a good compromise.

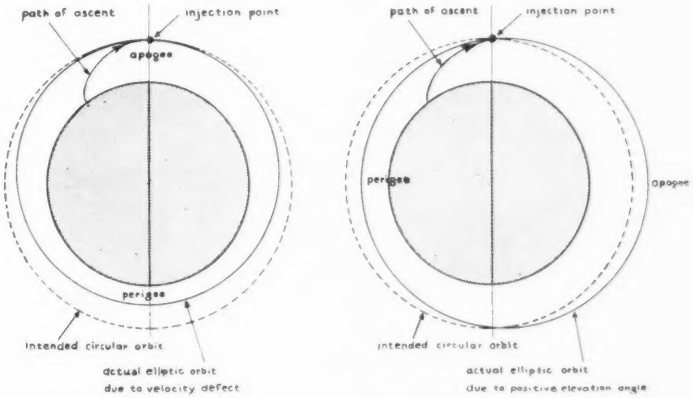
The inclination of the orbit can be computed by a simple rule of spherical trigonometry. If C is the compass angle of the launching direction measured from the East, and if L is the latitude of the launching site, then the compass angle E of the flight path crossing the equator is given by the formula: $\cos E = \cos L \cdot \cos C$.

Thus, a launching from Cape Canaveral, Fla., at 28.5 deg latitude in a direction 30 deg south of east would produce an orbit inclined at 40.5 deg, and the first sighting of the satellite at the Equator would show it traveling in a direction 40.5 deg south of east. (This calculation should actually be modified by using the "orbit injection" latitude instead of the launching site latitude, and allowance must be made for the effect of the earth's rotation on the injection vector, but the principle is the same.) As the earth rotates underneath the orbit, all the nations that lie between latitudes of N40.5 deg and S40.5 deg will pass below it.

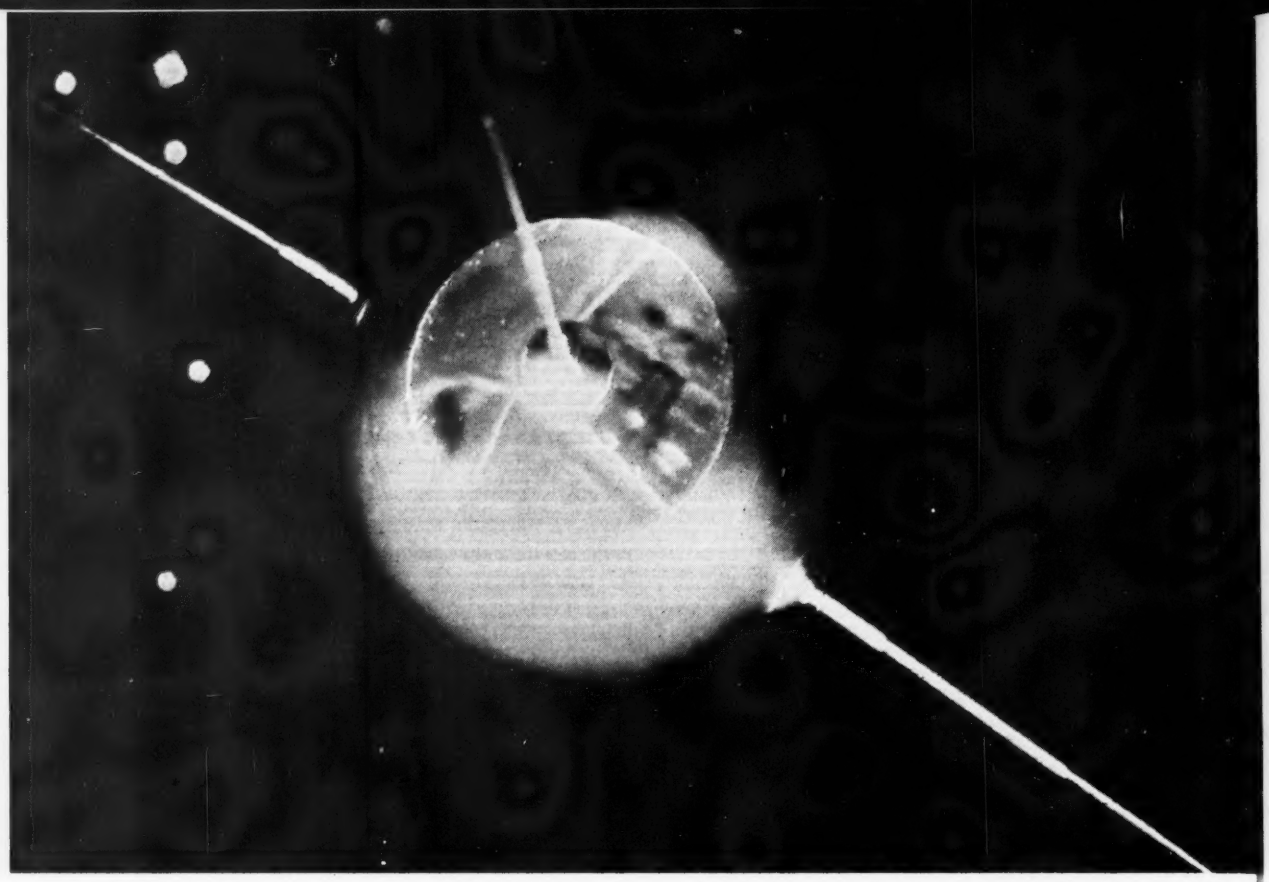
Before discussing the choice of altitude for the orbit and its eccentricity, it is necessary to consider the question of required launching energy, satellite velocity and period of rotation.

Launching Energy Requirements

We consider a spherical earth of radius R, and a satellite at a radial distance r from the center of the earth in a circular orbit. This is illustrated on page 19. As the satellite speeds around in its path, the outward centrifugal force is balanced by the inward attractive force of gravity. The circular velocity V_c and the period of revolution T are readily calculated as functions of the altitude h above the earth's surface. To be (CONTINUED ON PAGE 86)



Consequences of error in satellite injection.



Model of a Soviet earth satellite which was displayed in an exhibition last month in Prague, Czechoslovakia, marking the anniversary of the October revolution.

The meaning of "Sputnik"

We learn a new word and gain a healthy respect for Soviet technology amid the surprise, elation and chagrin marking the successful launching of the first earth satellite, a major step toward space conquest

By Irwin Hersey

"IT'S A magnificent feat, but how did they ever get so far ahead of us?" That pretty well sums up the reaction that still prevails among U. S. laymen and scientists alike to news of the successful launching by the U.S.S.R. of the first earth satellite.

Out of the initial confusion, wonderment and more than a little scientific chagrin that followed the Moscow announcement of the feat, the one fact that emerged with an irrefutable "beep" was that Russia had managed to put a satellite in orbit and, by so doing, had stolen a significant march on American science.

Other facts that emerged during the first few days after the successful launching were few, somewhat vague and changing hour by hour. Briefly, however, they were these:

• On Friday, Oct. 4, Moscow announced that the first satellite had been successfully launched in the U.S.S.R. that day, and that it was fitted with radio transmitters continuously emitting signals.

• According to the initial Russian announcement, the satellite was a test vehicle and had been launched on the first try. Russian sources described the satellite as spherical in shape, $22^1/_2$ in. in diam

U. S. VERSUS RUSSIAN SATELLITES

	Sputnik	Vanguard
Trajectory	First stage engine fires for 1 to 2 min, accelerates rocket to 4340 to 4650 mph. At an altitude a little above 1 mile, rocket starts to incline; at first stage burnout and drop-off, rocket is at 45° angle to earth's surface. Second stage boosts speed to 11,160 to 12,400 mph, drops off. Rocket coasts up to parallel attitude, about 625 miles from launch site. Third stage then accelerates rocket to 18,000 mph; satellite separates	First stage motor burns $1^1/_2$ min, pushes rocket to 4000 mph. Rocket goes straight up for 1 mile, starts to incline; at first stage burnout, rocket is 36 miles up, inclined 45° to vertical, and 230 miles from launch point. Second stage boosts rocket to 10,000 mph; vehicle coasts elliptically up to 300 miles and parallel attitude about 900 miles from launch site. Second stage drops off; third stage ignites, pushes rocket to 18,000 mph. Satellite separates
Size	$22^1/_2$ in.	6 to 36 in.
Weight	184 lb	22 lb
Injection altitude	About 300 miles	300 miles
Injection angle	65° to equator	35° to equator
Orbit		
Apogee and perigee	560 and 300 miles (estimated)	1500 and 200 miles (limits)
Period	96.2 min.	90 min.
Shape	Nearly circular	Elliptical
Average speed	17,896 mph (2nd day)	.....
Instrumentation	Radio transmitters, batteries, antennas, possibly telemetering equipment	Radio transmitter, solar batteries, antennas (1st test satellite)
Transmitting frequency	20.002 and 40.005 mc	108 cm

Note: Material on Soviet test vehicle was compiled principally from Russian announcements.

and weighing 184 lb. Altitude was said to be about 560 miles; speed, about 18,000 mph; period of orbit, 1 hr 36.2 min; angle of orbital plane to equator, 65 deg. Exact path and lifetime of the satellite were not given, although it was noted that it was expected to disintegrate upon re-entry.

• Receivers outside Russia began picking up signals from the satellite, the word for which in Russian is "Sputnik," within hours after the announcement.

• An RCA radio receiving station at Riverhead, N. Y., picked up the first satellite signal heard in this country at 8:07 p.m. (EDT) on Oct. 4.

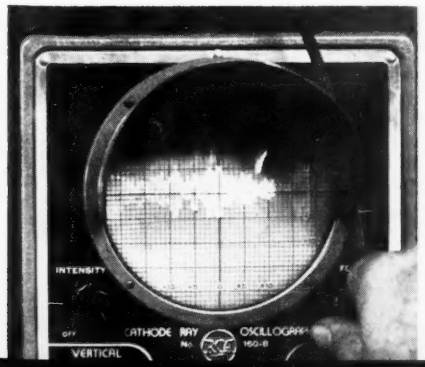
• After setting up special antennas and making other changes in Minitrack equipment, NRL scientists began to pick up satellite signals on Saturday, Oct. 5.

• First confirmed U. S. visual observation of the satellite was made at the University of Alaska's Geophysical Station at College, Alaska, on Oct. 6.

• First U. S. plot on the satellite on Oct. 6 placed it at an average altitude of 400 miles. Calculating backwards, NRL scientists figured the satellite had been launched in a northeasterly direction from a site north of the Caspian Sea at about 5 p.m. (EDT) on Oct. 4.

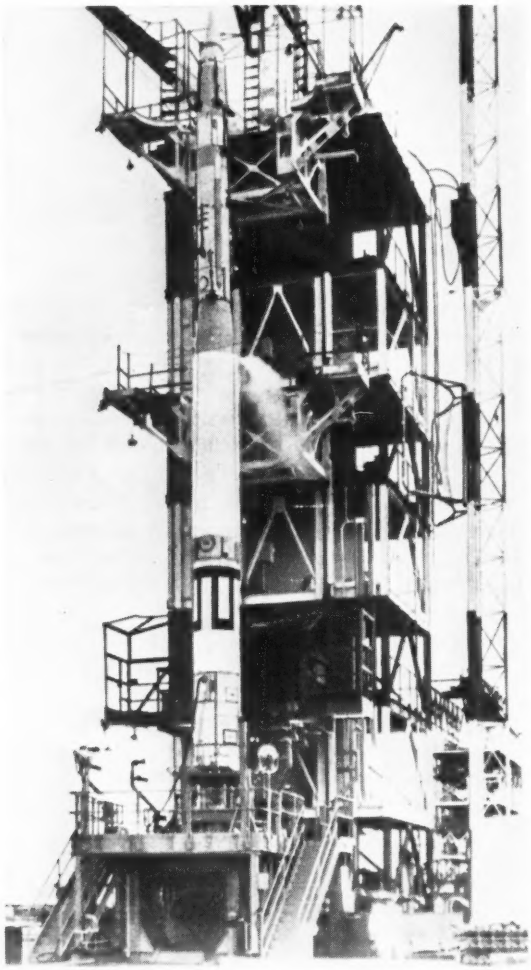
• On Oct. 7, Russia announced that part of the rocket used to launch the satellite, was also in orbit,

Close-up of oscilloscope at RCA Radio Receiving Station in Riverhead, N. Y., receiving signal from Soviet satellite early in its flight.



A. A. Blagonravov (left) and A. M. Kasatskin, Soviet delegates to the international conference on IGY satellite and rocket firings in Washington, discuss the Red satellite orbit after hearing news of successful firing.

John Mengel, chief of NRL Guiding and Tracking Div., inspects one of six hastily built antennas used at Blossom Point, Md., Minitrack facility to track Russia's artificial moon.



Vanguard launching vehicle TV-2 ready for test at Cape Canaveral. Vehicle consisted of prototype first stage and dummy second and third stages, had external appearance of final launcher.

about 600 miles behind the satellite itself.

• The following day, Anatoli A. Blagonravov, chief Russian delegate to the Washington conference on IGY rocket and satellite firings (see page 85), offered NRL accommodations on one of the Soviet satellites for John Townsend's mass spectrometer experiment, because he had heard no space was available in the proposed American satellite packages.

• On Oct. 9, a story in Pravda said the empty nose cone of the third stage of the launching vehicle was also in orbit.

Meanwhile, the reactions of leading American scientists and officials, registered within the first few days after the Soviet feat, ranged all the way from amazement and admiration to bitter charges of administrative bungling.

Among other things, the news gave added emphasis to earlier Soviet claims concerning its long-range missiles. More important, it cast rather significant shadows on the reliability and efficiency of the U. S. intelligence network.

News Came As Major Surprise

There can be little question that the Russian news came as a major surprise. Few U. S. scientists figured a Russian satellite launching would come as early as it did, that the orbit would be nearly circular or established at such a high altitude, and most astounding of all, that the satellite would be as heavy as it was—some 184 lb, or about nine times as much as the weight of the proposed full-scale U. S. satellite.

Joseph Kaplan's comment perhaps best summed up the reactions of top American scientists to the Russian announcement. The Chairman of the U. S. National Committee for the International Geophysical Year said: "I think it was a remarkable feat on their part . . . really fantastic. And, if they can launch that, they can launch much heavier ones."

The presence of a Soviet delegation from the satellite and rocket field in Washington when the news broke aroused hopes that additional details about Sputnik would be made available. However, neither Dr. Blagonravov nor his two companions, A. M. Kasatskin and Sergei M. Poloskov, provided any significant information that had not previously been announced in Moscow.

Asked why the Russians had failed to notify IGY officials that a Soviet satellite launching was imminent, Dr. Blagonravov, a member of the Presidium of the Soviet Academy of Sciences, replied that this was a test vehicle only, and not part of the regular IGY program. He also noted that a paper presented at the Washington conference before the event had mentioned the fact that Russia was "at the point of"

Homer E. Newell (left), of USNC-IGY earth satellite technical panel, J. W. Townsend (center) of U. S. rocketry panel and R. W. Porter, chairman of U. S. satellite panel, attempt to establish orbit of "moon."

Gathered around optical calibrating apparatus at Blossom Point, Md., Minitrack test facility, U. S. and foreign scientists attending Washington conference peer at the sky for signs of "Sputnik."

or "on the eve of" such a launching, but that this had been incorrectly translated as "in the near future."

Amid the confusion attendant upon hurried efforts by American scientists to track the satellite, not visible over the U. S. in the early stages of its flight, monitor its signals and establish its orbit, a question arose as to whether the CW signal it was emitting was coded. Dr. Blagonravov at first denied that the signal was coded, later changed his mind and said it might have been, adding that the satellite which was launched might have been the second, rather than the first, of two which had been made ready for flight. In this event, he noted, the satellite could have been sending back coded information about temperatures.

While there was still no official confirmation that Dr. Blagonravov's guess was correct, an indication that it was the second satellite that was actually fired was given in a story in the Soviet newspaper Pravda on Oct. 9 which confirmed the fact that the satellite was sending code signals giving temperatures and other data.

The same story added a few nontechnical details about how the satellite had been launched, noting that the successful launching "confirmed the correctness of the calculations and basic technical solutions made in designing the carrier rocket and the satellite." It also noted that the rocket had been fired vertically.

Pravda said the satellite's orbit was an ellipse but that, with the passing of time and the meeting of resistance encountered in the upper atmosphere, the orbit would gradually take on a circular shape.

There were few predictions as to how long the satellite would remain in orbit, either from Russian sources or American scientists. A theoretical paper on satellite lifetimes presented by Dr. Blagonravov at the Washington meeting did, however, offer some hints. The Soviet scientist noted that a satellite $^1/_2$ m in diam with an apogee of 860 km and a perigee of 800 m—in other words, a near-circular orbit—would have a lifetime of approximately three months.

Meanwhile, the big question in the minds of American scientists continues to be: How did they do it?

Says Military Hardware Was Used

One suggestion was advanced by Heinz H. Koelle, chief of preliminary design of the Army Ballistic Missile Agency, in a timely paper presented last month at the International Astronautical Federation meeting in Barcelona (see page 36). Dr. Koelle believes the Russians simply used existing hardware that had been developed for military purposes. The Russians have consistently denied this, but the theory has picked up a number of adherents, especially in view of Soviet reluctance to reveal any details about the satellite launching vehicle.

A broader view was contained in a by-lined article in the *New York Times* a few days after the satellite was launched by Harry Schwartz, one of the most knowledgeable reporters on the Soviet system in this country.

In a penetrating analysis which set aside for the moment the technical details of the launching, Schwartz pointed out the feat could only have been accomplished by a nation having top-flight scientists, technical personnel and facilities over a wide range of basic sciences, including, among others, mathematics, physics, (CONTINUED ON PAGE 83)

The anthropology of astronautics

A searching examination by one of the leading thinkers in our field of the implications of space flight and its challenge to human destiny

By Krafft A. Ehricke

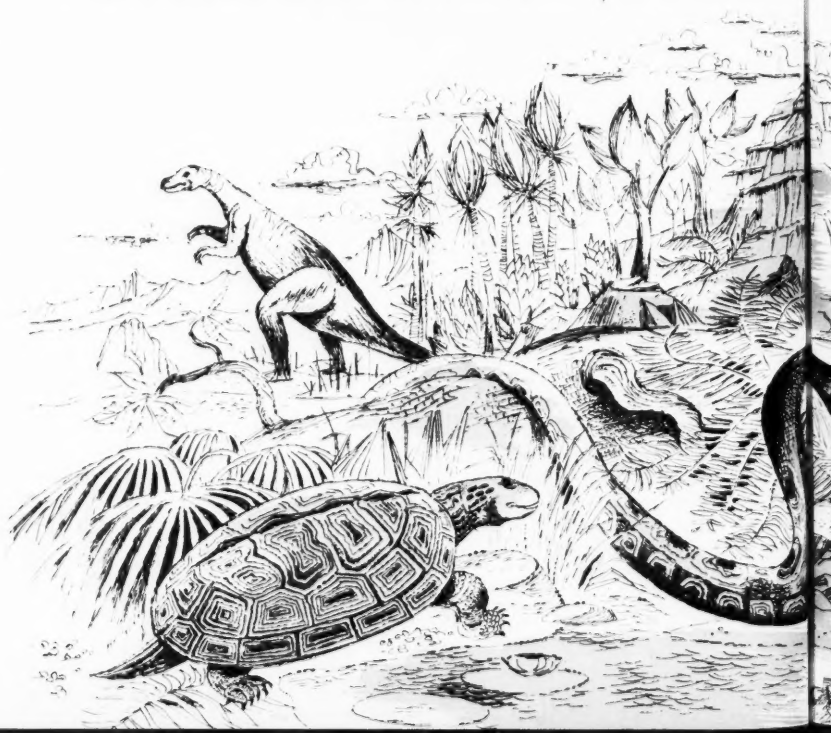
CONVAIR, A DIVISION OF GENERAL DYNAMICS, SAN DIEGO, CALIF.

Krafft A. Ehricke is assistant to the Technical Director of the Astronautics Division of Convair in San Diego. After graduating as an aeronautical engineer in Berlin, Germany, he worked at Peenemünde on the V-2 project. In 1945 he obtained a contract from the Dept. of the Army. He worked from 1947 to 1950 as research engineer on ramjet and rocket systems at Ft. Bliss, Tex., and from 1950 to 1952 was at Redstone Arsenal, Ala., where he headed the Gasdynamics Section. From 1952 to 1954 he was with Bell Aircraft Corp. in Buffalo, N. Y., as preliminary design engineer. In 1954 he joined Convair, San Diego, as Design Specialist. Prior to his present position, he built up the Preliminary Design and Systems Analysis Group of the newly established Astronautics Div., and headed it for some time.

ALTOGETHER, in the United States and other countries, billions of dollars are now being spent on the development of a technology which gives every indication of being or becoming an astronautical technology. This is extremely gratifying to all those who, during the first part of this century, fought for recognition of space travel as a serious, practical and worthwhile effort—not at some future time, but right now, in this century and in this age of ours.

The campaign for technical and scientific recognition of space flight is won. However, the fight for recognition of astronautics as a vital part of man's future, rather than as just an accepted technical or scientific specialty, has hardly begun. Astronautics is the science of operating in space and traveling to other worlds. The implications are such that it now becomes increasingly important to develop the philosophy, as well as the utilitarian aspects, of this new science.

Since space travel has been recognized by its protagonists as one of the most fundamental and outstanding concepts in the history of man, it is not surprising that a good deal of thinking has already been done on this subject, beginning with Konstantin Ziolkowsky, whose ardent belief in the cosmic mission of mankind heralded the dawn of astronautic pioneering some 60 years ago, and continuing with Hermann Oberth, Willy Ley, A. C. Clarke, A. V. Cleaver, Wernher von Braun and Eugen Saenger. A certain mutual overlapping of thoughts and arguments advanced by these pioneers and others is



$\frac{F}{m} = V^2$
$g = G\frac{m}{r^2}$
$P = \frac{1}{T}$
$oc^2 = 4 \cdot 10^6$
$z = \frac{v^2}{r}$

THE THREE FUNDAMENTAL LAWS OF ASTRONAUTICS

First Law:

Nobody and nothing under the natural laws of this universe impose any limitations on man except man himself.

Second Law:

Not only the earth, but the entire solar system, and as much of the universe as he can reach under the laws of nature, are man's rightful field of activity.

Third Law:

By expanding through the universe, man fulfills his destiny as an element of life, endowed with the power of reason and the wisdom of the moral law within himself.

unavoidable, in view of the principal agreement among all concerned over the promotion of space travel.

However, the philosophy of astronautics is young and fertile. Its countless implications are far from exhausted. For this reason, the author, concerned for some 20 years with the study and the advocacy of astronautics as a technical, as well as a cultural, mission, submits a few additional thoughts on this subject.

The concept of space travel carries with it enormous impact, because it challenges man on practically all fronts of his physical and spiritual existence. The idea of traveling to other celestial bodies reflects to the highest degree the independence and agility of the human mind. It lends ultimate dignity to man's technical and scientific endeavors. Above all, it touches on the philosophy of his very existence. As a result, the concept of space travel disregards national borders, refuses to recognize differences of historical or ethnological origin, and penetrates the fiber of one sociological or political creed as fast as that of the next.

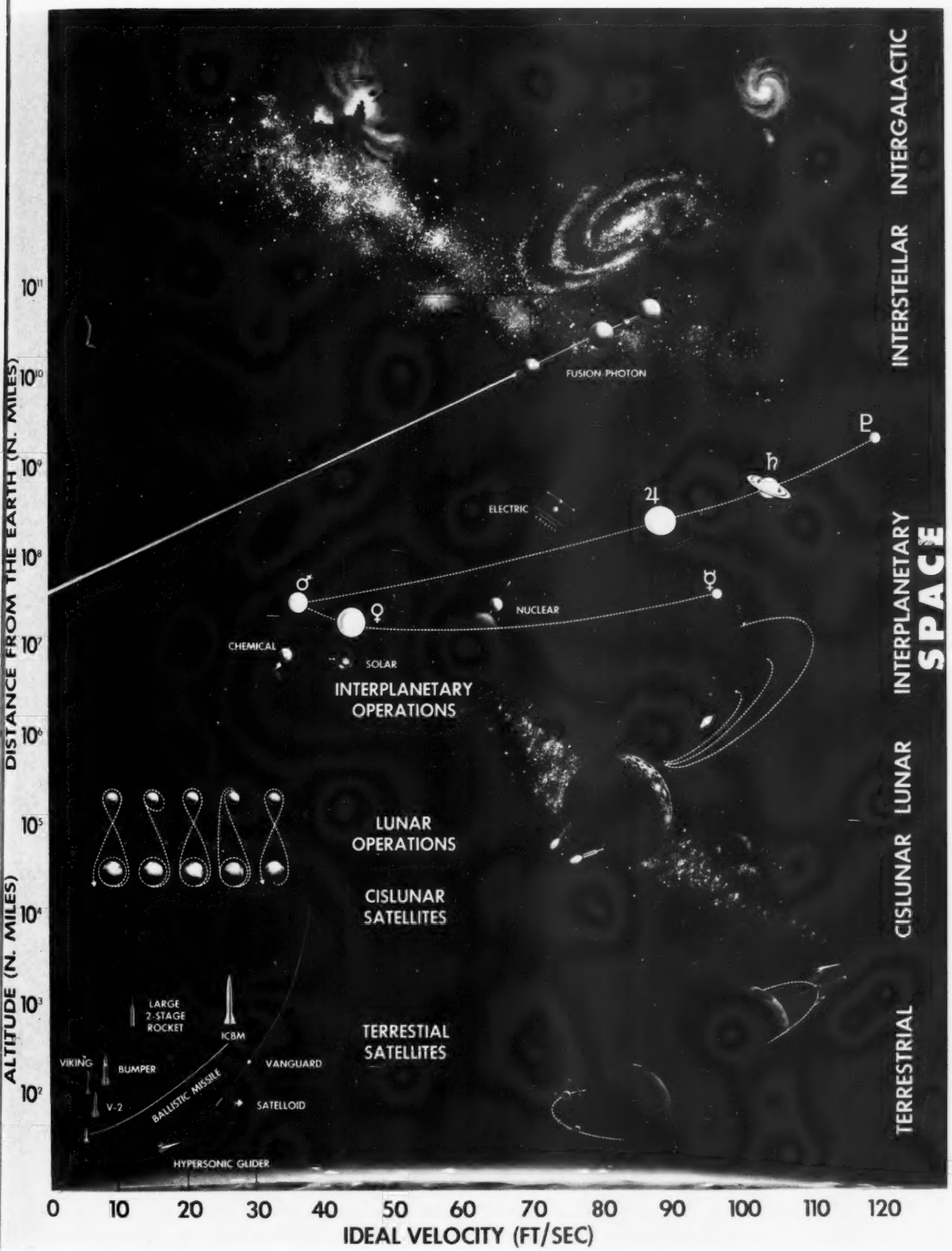
As a technical concept, astronautics is all-embracing, and more revolutionary than anything conceived so far, including even atomic technology. As a scientific concept, it is bound to stimulate and rejuvenate practically all fields from astronomy to zoology. Its sociological and political implications are such that future generations may well describe as "cautious" even the boldest predictions of our time.

A Moving Spirit

Because of this, space travel holds perhaps the greatest general appeal for our complex and divided world. It seems to promise less immediate material gain than atomic technology. Yet, or perhaps therefore, its spiritual appeal is extremely powerful, symbolizing as it does that man, after all, has not yet lost his capability of cutting the Gordian knot, of exploding old notions which retard his development and of overcoming seemingly invincible physical obstacles.

If it can be done here, it can eventually also be done in other segments of our life today, where man seems to be hopelessly and perpetually deadlocked. A feeling of enthusiasm and genuine interest seems to prevail among all those who deal with space flight and astronautics—school (CONTINUED ON PAGE 65)

THE NEW AGE OF DISCOVERY. Man, the cosmic amphibian, propels himself into cislunar, interplanetary and interstellar space, using various means of propulsion commensurate with the increasing energy requirements of astronautical operations. Abscissa correlate energy with altitude or distance on ordinate and with destinations in ruled portion of picture. Energy is given as velocity, equivalent to total energy expenditure of mission. Several lunar operations are indicated. For planetary operations, two-way Earth-Satellite to Earth-Satellite flights are assumed, with satellite capture near target planet, but no descent to surface.


INTERGALACTIC
INTERSTELLAR
INTERPLANETARY
SPACE
CISLUNAR
LUNAR
TERRESTRIAL
FUSION-PHOTON
ELECTRIC
NUCLEAR
CHEMICAL
SOLAR
INTERPLANETARY OPERATIONS
LUNAR OPERATIONS
CISLUNAR SATELLITES
TERRESTIAL SATELLITES
LARGE 2-STAGE ROCKET
ICBM
VIKING
BUMPER
VANGUARD
V-2
BALLISTIC MISSILE
SATELLOID
HYPERSONIC GLIDER
DISTANCE FROM THE EARTH (N. MILES)
ALTITUDE (N. MILES)
IDEAL VELOCITY (FT/SEC)
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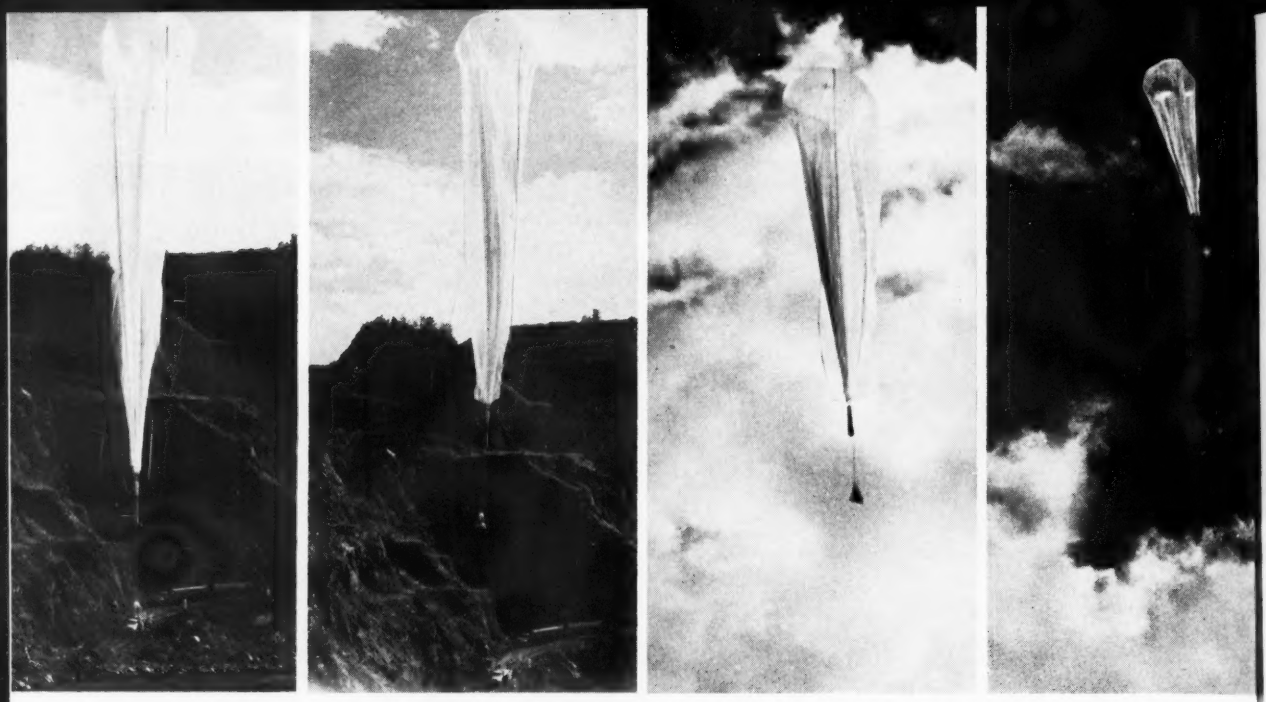


Rising up from its wind-sheltered launching pit, MANHIGH balloon, with Major David Simons aboard, quickly breaks through cloud cover and heads for the edge of space.

The first space man

Here, for the first time, is a step-by-step report of the 32-hr balloon flight of Maj. David G. Simons to an altitude of 100,000 ft

By Col. John P. Stapp

CHIEF, AERO MEDICAL FIELD LABORATORY, HOLLOMAN AFB, N. M.

THE two-hour flight of Capt. Joe Kittinger in the MANHIGH gondola lifted by a polyethylene balloon to 96,000 ft, described in the August issue of ASTRONAUTICS, was the successful preliminary to Maj. David G. Simons' 32-hr flight to 100,000 ft on the 19th and 20th of August.

Maj. Simons' flight employed a 3-million-plus cu ft balloon of 1.5 mil polyethylene whose size and delicacy required still air for inflation and launching. Furthermore, the 1800-lb weight of the gondola and experimental packages and 900-lb weight of the balloon constituted about twice the weight that was carried in the test flight.

Inflation with helium to more than 3200 lb of lift provided a difference of more than 500 lb which would insure an ascent of more than 1000 fpm to carry the balloon through an atmospheric temperature inversion at an altitude of 22,000 ft.

On the morning of the 18th, a firm prediction of surface winds of less than two knots at Crosby, Minn., for the morning of the 19th, started the carefully arranged routine for the balloon launch. Maj. Simons got what rest he could between the taking of hourly blood samples until 6 p.m. He was then put into the M3 pressure suit and sealed in the gondola with all his equipment. Pressure checks and communications checks were made and the gondola was loaded on an "A" frame surrounded by a plywood windshield on a stake truck. A ghostly procession, with the stake truck in the lead, the Navy radio truck-trailer and command post next, and various cars, station wagons and trucks required in

the operation, left the Winzen, Inc., plant in Minneapolis shortly after midnight.

During the 150-mile journey to the Crosby open pit of the Hannah Iron Mine Co., denitrogenation was accomplished on Maj. Simons by replacing part of the capsule atmosphere with helium and oxygen. This required approximately two hours. Preparations for the launch began at about 5 a.m., approximately one hour behind schedule. Fog shrouded the mouth of the pit, but the cold damp bottom 400 ft below was clear.

How Balloon Was Inflated

Smoothly and rapidly, the balloon was laid out on a 280-ft length of soft white cloth. Under the instructions of Otto Winzen, who directed the entire operation from the ground, the balloon was inflated enough to raise its own weight, and its red plastic sheath was gradually pulled down as inflation proceeded. It was at this point that Mrs. Winzen, expert amateur photographer, took the picture which appears on the cover.

At the same time, all instrumentation checks and final preparations of the gondola were accomplished by the expert team trained by Mr. Winzen and using the experience gained from more than 760 balloon launches. Presently, the second helium truck and the second inflation sleeve of the balloon were put into action to accelerate inflation. The load ring of the balloon was attached to a winch on a bulldozer with enough slack to allow a dynamometer to measure the lift. When the dynamometer registered more than 3200 lb of lift, the helium was shut off.

Workmen on top of the bulldozer then tried to strip off the remaining 30 ft of red plastic sleeve encasing the lower end of the balloon. They split the plastic upward to the fiber glass guard ring at its upper end. As the tug pulled the ring downward, the plastic ripped off, leaving a ring of 500 lb test fiber glass girdling the balloon. This meant the balloon could not be launched without bursting, as the gas expanded above this constriction.

An extension ladder was found and tied on top of the bulldozer. While six workmen held the swaying ladder with guide ropes, Mrs. Winzen inched her way up, hooking her elbow into every rung as she went, until she reached the top. Cautiously she reached up and leaned outward, and, as the ladder swayed toward the balloon, slipped her scissors carefully under the contricting band and snipped it in two. The constricting crease in the balloon snapped out, and MANHIGH was ready to go.

By this time, the flight was almost two hours off schedule and the fog had been blown away by a very light surface breeze. The top of the balloon began swaying. Quickly Mr. Winzen had the 40.4 ft cargo chute installed between the gondola and the load ring of the balloon, and the winch was payed out until the lift was transferred via the parachute by its attachment to the gondola. While workmen held the landing gear of the gondola, the stake truck began the slow descent into the pit toward a point where launch could be accomplished without banging the balloon and its gondola against the craggy sides of the pit. By this time, the rising wind made it necessary to halt while the balloon leaned over, and to move only between gusts. Mr. Winzen never hesitated when he saw that further delay would be dangerous. He stopped the truck and the crew cut the ropes, walked the gondola away from the stake truckbed and hurled it upward as soon as the gondola was lined up vertically with the balloon.

Maj. Simons never felt the gentle rise, but reported that he saw the ground falling rapidly away as he ascended at more than 1200 fpm. There were cheers of relief as the great bag cleared the opening of the mine shaft and lifted strongly toward the broken overcast.

Radio communications with Maj. Simons continued from the buildings near the pit while the caravan got organized for (CONTINUED ON PAGE 82)

CLOSE QUARTERS: Major Simons undergoes claustrophobia tests before his 32-hr solitary sojourn inside the close-fitting MANHIGH gondola.

Weightlessness

When man starts going places by rocket, chances are he won't have to worry about conventional air sickness, but he may have some trouble with this new phenomenon, which can do strange things to some people

By Siegfried J. Gerathewohl

USAF SCHOOL OF AVIATION MEDICINE, RANDOLPH AFB, TEX.

After obtaining his Ph.D. in psychology and physiology, the author began his career as a military psychologist with the German Army in 1936. In 1938, he became an aviation psychologist with the rank of captain in the German Air Force. Subsequent advances brought him his majority and, in 1944, the job of Chief Advisor, Human Engineering Branch, Aeronautical Research Institute, Munich.

Dr. Gerathewohl came to the U. S. after the war and joined the AF School of Aviation Medicine, where he now holds the title of Advisor on Space Psychology. His particular areas of research at present are the psychophysiological effects of weightlessness, parabolic flights, visual and orientation problems in space flight, radar and visuo-electronic landing aids for high performance aircraft, and gravics.

LAUNCHING a big rocket is a dramatic event. It starts with technical preparations on the ground: Instrumentation, calibration and fueling. Then comes the roaring thunder of the engine, the slow initial rise and the fast ascent. After the rocket has reached its highest velocity, the third phase—free cruise at zero acceleration—begins.

This is not the place to discuss the physical conditions and principles of rocketry. However, it does seem appropriate to mention that rocketry has spawned a new branch of science which can be properly designated as "gravics." The term is derived from the Latin word *gravitas*, meaning heavy. Thus gravics is another field among the many technical and scientific areas of astronautical research, as are, for example, aerophysics, astrionics, cybernetics and electronics. This new field of gravics includes studies on acceleration, gravity, and weight, particularly with regard to their effects upon the human body.

Let's take a look at some of the problems involving human exposure and tolerance to weightlessness.

In rocket flight, the occupants of a man-carrying vehicle will be subjected to environmental changes of a considerable degree. After a short period of relatively high acceleration, resulting in an increase of their apparent weight, these occupants will find themselves in a state of "zero-gravity" and "weightlessness." If we assume the vehicle is moving in a near vacuum, or under conditions as they prevail outside the earth's atmosphere, it will follow a true Keplerian trajectory, which can be represented mathematically by an ellipse or approximated by a parabolic arc.

What Is Weightlessness?

The rocket and its occupants are, of course, still under the earth's gravity, and, as a matter of fact, the vehicle's motion is determined by the force of gravity whenever it moves within the gravisphere of our planet. Moreover, the occupants of the vehicle are weightless only with regard to the vehicle, and not with respect to earth. For this reason, it is not quite appropriate to use terms like "zero-gravity" or "gravity-free" state to describe the condition of freely falling

Mercury floats inside bottle during lack of appression.

objects, and even the term "weightlessness" must be newly defined.

On the other hand, the latter term was introduced mainly to characterize the psychological experience of weightlessness. The word was used to describe the subjective symptoms experienced by every aviator or any person who has been exposed to that condition, which, as one of our subjects expressed it, made him "feel somewhat like floating in water of just the correct degree of salinity to provide sufficient buoyancy to balance the body's weight."

Some examples of the physical effects associated with lack of appression and with weightlessness are shown in the photographs at right.

It Makes a Difference

These pictures show not only that the weightless state can be realized by the use of aircraft, but also demonstrate very strikingly the changes in the behavior of physical matter. Extrapolating from these findings, we may hypothesize that the organism, and thus the various sensations, responses and behavioral patterns, of man, are affected in a similar way.

Everyone knows the feeling of comfort and relaxation that comes when you're settling down for a rest, or the exciting tickling sensation in the stomach and the associated exhilaration that causes girls to scream while on a roller coaster. But there also is the possibility of severe attacks of motion sickness, or even of an incapacitating autonomic storm, because of sensory inconsistencies, illusions and overstimulation.

The symptoms associated with weightlessness are manifested in many ways and are experienced so differently by man that a clearer picture must be obtained before we can predict the response of an individual. Nevertheless, tolerance to the weightless condition becomes an important problem in the assessment and training of rocket crews, as well as in providing passenger comfort in future rocket ships. It is true that with the means available at present the weightless state can be produced for a period of about 45 sec at most. However, with the development of aircraft with higher speeds and higher ceilings, and with the construction of the first rocket craft for

Movie camera catches the author's reaction as he watches "weightless" water droplet hang in mid-air.

Maj. H. D. Stallings (left) and the author (right) discuss results of weightlessness experiment with Dr. Hubertus Strughold after jet ride along a parabolic arc.

systematic experiments on human factors, the exposure time of the human subject can be extended satisfactorily.

In 1955 and 1956, a variety of experiments on human behavior during lack of appression was conducted at the School of Aviation Medicine, USAF. The agravic condition and the subjective experience of weightlessness associated with it was obtained by flying a jet-type aircraft on a Keplerian trajectory. The aircraft used was either a Lockheed T-33A or—since the spring of 1956—a Lockheed F-94C Starfire. After preliminary flight tests it was found that the best working altitude for both types of aircraft was between 17,000 and 23,000 ft because of the usual lack of turbulence and clouds at this height, and because of the degree of safety in the event of an emergency.

Two Different Patterns Employed

Two different flight patterns were employed. The first consisted of four individual parabolas started at an altitude of about 21,000 ft with the T-33, and at about 23,000 ft with the F-94. After a shallow dive to 17,000 ft the pilot pulled the aircraft out smoothly so that an acting force of 1.5 g was not exceeded. He then put the aircraft into a 60 deg climb at full throttle and initiated a pushover, using the inertial effect for counteracting the gravitational pull of the earth. (CONTINUED ON PAGE 74)

HOW IT FEELS TO BE WEIGHTLESS

Responses of 47 human subjects to short periods of weightlessness

Group	No. of subjects	Attitude prior to flight	Psychological reactions	Physiological symptoms	Autonomic disturbances
I	22	Normal, or slightly apprehensive	Sensation of rest or slow floating; feeling of well-being, comfort, pleasure, relaxation, enjoyment and exhilaration; same experience during repeated exposure; euphoric or enthusiastic responses.	Tingling and "light" feeling at abdomen; slight giddiness; slightly increased perspiration; hyperventilation; hyperactive Patellar reflex.	None
II	11	Normal, or slightly apprehensive	Sensation of floating or tumbling forward and backward; sensation of falling or lift during transition; sensation of standing on head, or being suspended in an inverted position; mildly elated situation, neither unduly pleasant nor exactly comfortable.	Slightly disoriented when eyes open; more disoriented with eyes closed; mildly dizzy and nauseated with increasing hot or cold feeling, perspiration and hyperventilation; tired and sleepy after exposure; no appetite for several hours.	Moderate degree of nausea; mild vertigo, especially during rolls and increased GNF.
III	14	Normal, or slightly apprehensive; occasionally fear and acute anxiety prior to and during flight	Sensation of floating, drifting and tumbling; sensation of falling forward or rolling over; "light" or "strange" feeling in head and stomach; pleasant in the beginning with increasing experience of discomfort.	Symptoms of generalized motion sickness including sweating, dry throat, increased salivation; feeling of coldness or heat.	Vertigo and nausea; vomiting during flight.

Fuels for the future

Free radicals, subject of three-day symposium in Washington, show great promise as energy source for tomorrow's vehicles

FREE radicals, perhaps the most promising rocket fuel of the future, were scrutinized from all angles in Washington recently at the first scientific symposium devoted exclusively to the elusive molecular fragments.

For missile men, the only paper of direct interest was presented by George Moe, head of free radical research at Aerojet-General Corp. At the same time, however, a well-known biologist warned rocketeers that free radicals could cause cancer.

Barry Commoner of Washington University, St. Louis, urged handlers of free radicals not to treat them like sugar. "I wouldn't get too much on my skin, nor ingest any. And I certainly wouldn't inhale any," he cautioned. While acknowledging that no evidence of this suspected carcinomic effect was available, he pointed out that "there hasn't been time for rocketry to enter public health statistics."

Dr. Commoner and his associates proved last year that free radicals play a vital role in life processes. Chemical reactions within living cells would not occur without the electron-passing abilities of the short-lived particles.

Use in Rockets Many Years Off

Free radical propulsion of rockets is many years off, according to things said and unsaid at the conference. The materials are still the subject of basic scientific research, although most of the aircraft firms have committed men and money to their study.

Free radicals are uncharged atoms or pieces of molecules that are more stable when combined with other atoms or pieces of molecules. Highly energetic, they have lifetimes often measured in thousandths of a second. When they return to a more stable configuration, their great energy is released, as both heat and light.

Generally, free radicals are characterized by having an odd number of electrons. Hydrogen, for example, has one electron, chlorine has 17, the hydroxyl radical (OH) nine, and the methyl radical (CH_3) also has nine. They are generated by such high energy sources as an electrical discharge, ultraviolet light, or gamma radiation from such isotopes as Cobalt-60.

Relatively few free radicals are better than today's chemical propellants, however. These are the lightweight, short-lived atomic radicals, the best of which, from an energy standpoint, is hydrogen. Little force can be extracted from the ponderous hydrocarbon pieces so important in physiological work.

Great Interest in Subject

The overflow crowd of basic scientists attending the sessions at the National Bureau of Standards testified to the great interest being exhibited in such materials. More than 380 scientists from industry and universities, here and abroad, registered for the three-day symposium. Besides NBS, sponsoring groups included Johns Hopkins University, Catholic University of America, and the University of Maryland.

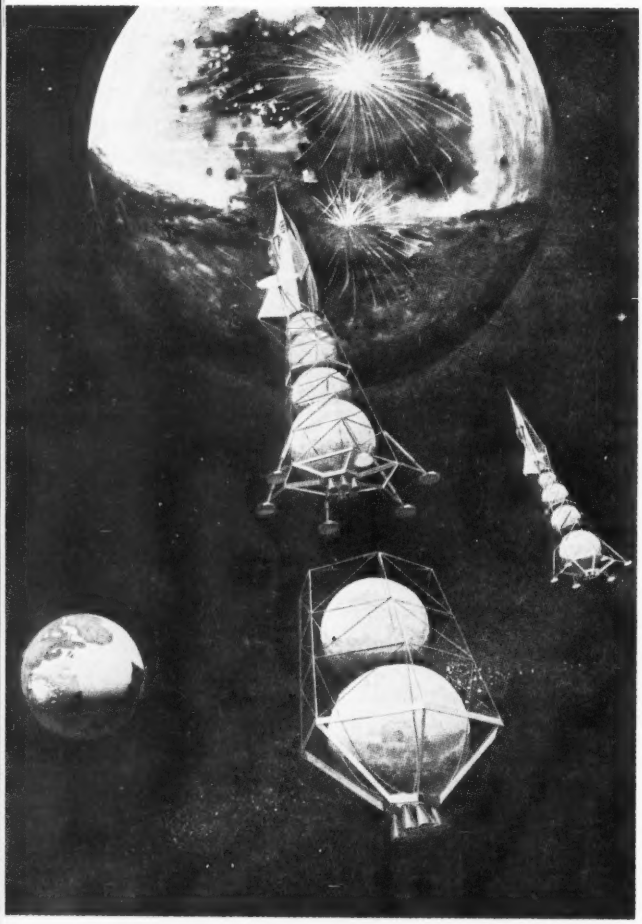
Dr. Moe reviewed the factors that made some free radicals attractive as rocket fuels of the future. Today's hydrocarbon propellants with liquid oxygen provide specific impulses of up to 280 lb force/lb mass/sec, or 280 sec. Probably the best combination now attainable, hydrogen and liquid ozone, would drive a rocket with 380 impulse units. These values are based on combustion temperatures of 3000 K, with rocket nozzle expansion ratio of 20 to 1.

Specific impulse is a direct measure of the force available in the propellant. The velocity of a rocket at burnout is directly proportional to this parameter, while the height attained by a rocket is proportional to the square of this factor. Free radicals can boost this specific impulse value dramatically.

With a mixture of 75 per cent free radicals of hydrogen in a working fluid (CONTINUED ON PAGE 80)

First look at American IAF papers

Eighth International Astronautical Congress at Barcelona brings past to present while taking long look at future of space flight



METEOR JR: This concept of a moon ferry could be a reality in eight years, say its sponsors.

SHOWING a decided preference for Mediterranean locales, IAF members changed their lire left over from last year's meeting in Rome into pesetas and headed for Barcelona and this year's VIIIth International Astronautical Congress. From Oct. 6 to 12, they packed the lecture halls of the Consejo Superior de Investigaciones Cientificas and listened to scientific papers touching upon practically all aspects of jet propulsion and space flight.

American authors dominated the technical sessions, accounting for about two-thirds of the papers presented. By and large, the authors devoted their time to expanding upon earlier conjectures and to updating previously published work.

Presented Paper on Space Navigation

UCLA's Samuel Herrick, Robert Baker Jr. and Charles Hilton, for example, were concerned with the revision of a paper published in January of this year, titled "Units and Constants for Geocentric Orbits." Now called "Gravitational and Related Constants for Accurate Space Navigation," the paper offered the latest determined values for all such constants, and should prove a handy reference work.

Ernst Stuhlinger of the Army Ballistic Missile Agency returned to a favorite theme, ionic propulsion, for his presentation. Some time ago, Stuhlinger described a space ship with ionic drive and nuclear power source, capable of going to Mars and back. For his Barcelona offering, as he phrased it, this study was extended and refined.

Another ABMA man, H. H. Koelle, made some interesting observations on Russia's proposed satellite in the introduction to his paper. "Optimization Considerations for Orbital Payload Capabilities."

According to Koelle, "it would be logical to assume that the Russians are using the powerful 264,000-lb thrust booster of their intermediate range ballistic missile as the basic booster of their three-stage orbital carrier and the improved 77,000-lb thrust V-2 missile as the second stage . . . The

improved Wasserfall engine with about 20,000-lb thrust, under development for almost a decade, might be a proper choice (for the third stage)."

Using proved hardware with established reliability appears to be an attractive approach, said Koelle. It promises a realistic schedule and offers an orbital vehicle with several hundred pounds payload capability, "at least 10 times as much as the first American orbital vehicle can carry."

Maj. Gen. H. N. Toftoy of Redstone Arsenal also followed this theme of military missile precursors for scientific research vehicles in his talk on the Army's support of scientific activities in astronautics. In Gen. Toftoy's words: "A rocket not only has the capability of carrying a warhead; it can also be equipped to carry scientific instrumentation and in this form it represents a scientific tool of almost fabulous potentialities." The General also touched upon the Army's support activities in connection with nonmilitary scientific ventures and upon the interplanetary communication work of the Signal Corps Engineering Laboratories.

W. Klemperer and E. Benedikt of Douglas Aircraft returned to the subject of orbital vehicles in their intellectual exercise entitled "Selenoid Satellites." Starting with a reference to the classical solutions of the three-body problem first postulated by Lagrange in 1772, the authors sought answers to the question: Under what conditions should it be possible to establish an artificial (unpowered) satellite on such an orbit that it remains in equilibrium in a constant configuration relationship with Earth and Moon.

Rand Corp.'s Carl Gazley Jr. and David Masson were more interested in getting an orbital vehicle down than keeping it up in their paper on the recovery of a circumlunar instrument carrier. The authors discussed, in order, possible paths for the lunar vehicle, tracking and impact location, atmospheric entry and the concomitant heating problem, and finally, design of the return package.

Dealt with Satellite Tracking

Satellite tracking was dealt with in more detail and on a less theoretical basis by Fred Whipple and J. Allen Hynek of Smithsonian Astrophysical Observatory. Their paper on the optical and visual tracking of artificial satellites was essentially an up-to-date review of the programs set up for the current IGY.

In another paper, "The Meteoritic Risk to Space Vehicles," Dr. Whipple took up the much-discussed subject of meteoritic particles—their origin, structure, velocities, size, density, and most important, their possible effects on space vehicles, i.e., punctures and surface erosion. (CONTINUED ON PAGE 72)

SOLAR FURNACE: Man has already exceeded the sun's capability.

WATER-STABILIZED ARC: A potential of 50,000 K makes it an important research tool.

Why astronautical engineers?

A thoughtful reader takes a close look at a recent proposal in these pages to establish still another curriculum and builds a case against too much specialization at the undergraduate level

By Gideon Kanner

ROCKETDYNE, A DIVISION OF NORTH AMERICAN AVIATION, INC.

AS MODERN technology makes progress and opens new fields, we find ourselves confronted with an ever-growing multitude of engineering specialties. This in itself is understandable, and even desirable. However, along with this trend, there usually comes a tendency to subdivide the engineering profession at the undergraduate level in accordance with these specialties.

Thus we find nuclear, electronic, sanitary and audio engineers taking their places alongside those in what could be called the "main" branches of the profession, such as the mechanical engineer, electrical engineer, etc.

A proposal to create still another new branch of this type, astronautical engineering, was made in the article by John Gustavson entitled "Why Not Astronautical Engineers?" in the September issue of ASTRONAUTICS (page 52).

Better Late than Early

The questions and problems raised by Mr. Gustavson's proposal touch on the old issue of early specialization versus a thorough grounding in fundamentals followed by specialization in graduate school. In the field of astronautical engineering, it would appear that the case for late specialization is the better one.

The modern missile (or future space ship, if you prefer) represents probably the most sophisticated creation of the various fields of modern technology. To fully understand it, one would have to be thoroughly familiar with the latest practices in electronics, structures, aerodynamics, propulsion, etc. This would seem to call for a highly diversified, rather than a specialized, individual.

In view of the above, it would appear most unlikely that an undergraduate curriculum could adequately cover these fields, in addition to the sciences and mathematics, as well as fundamental engineering subjects such as fluid mechanics, thermodynamics, etc., within the four years currently devoted to an undergraduate engineering curriculum.

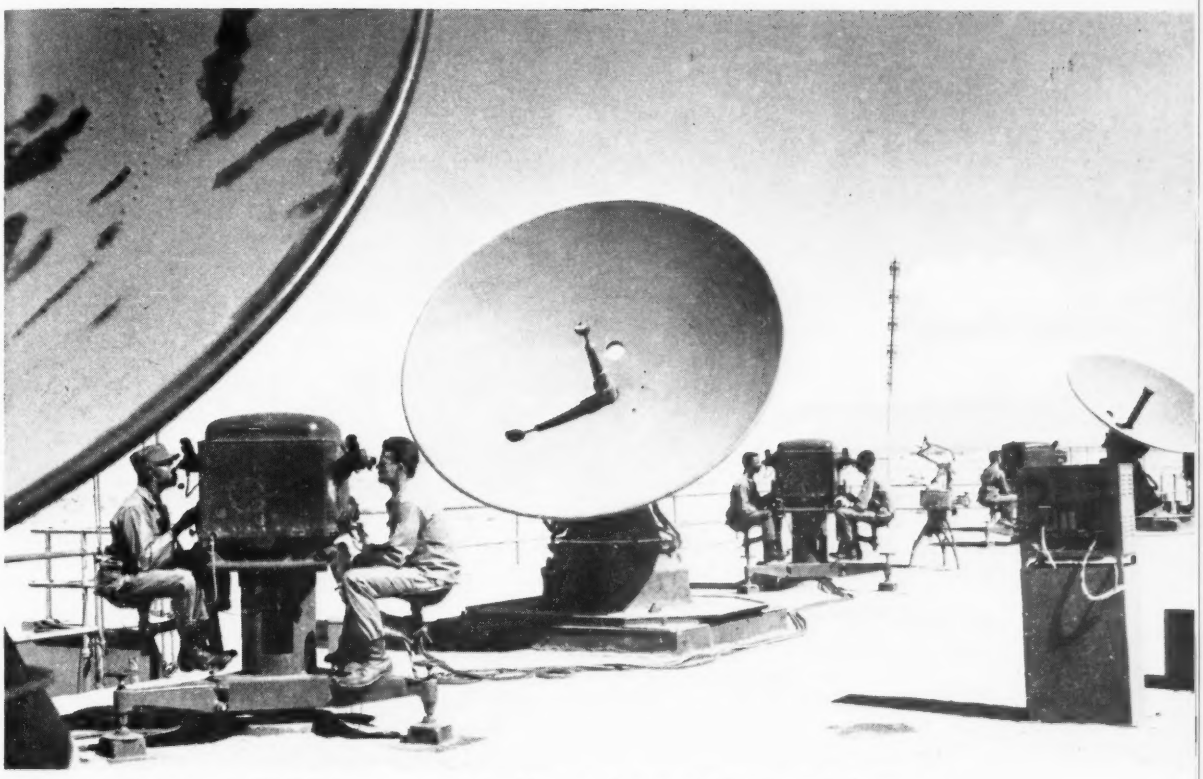
As it is, the engineer is often accused of being a narrow specialist who knows nothing outside his own field. The creation of overly specialized degrees of this type would not only strengthen this accusation in terms of general knowledge, but would also narrow down the specialist's knowledge of other (CONTINUED ON PAGE 68)

BACKGROUND

John Gustavson's article on astronautical education in the September issue of ASTRONAUTICS has been productive of a good deal of comment. Many readers agreed in principle with Mr. Gustavson's proposal for the establishment of an astronautical engineering curriculum at some of our universities; others, like the author, disagreed for various reasons.

Mr. Kanner's thoughtful article arrived in the form of a letter to the editor. However, his arguments against the establishment of yet another engineering curriculum and in favor of specialization in astronautics only after a thorough grounding in engineering fundamentals were so detailed that it was decided to publish the letter in this form.

The author received his B.M.E. from Cooper Union in 1954 and upon graduation was employed as a test engineer at the U. S. Naval Air Rocket Test Station at Lake Denmark, N. J. In 1955 he joined the Experimental Development Group of Rocketdyne, and he is currently Rocketdyne's representative-in-charge at Chrysler Corp. in Detroit. His carefully marshalled arguments against Mr. Gustavson's proposal may possibly be explained by the fact that he is now a second-year student at the Detroit College of Law.



Huge radar dishes atop AFMDC instrumentation building track test missiles through desert sky.

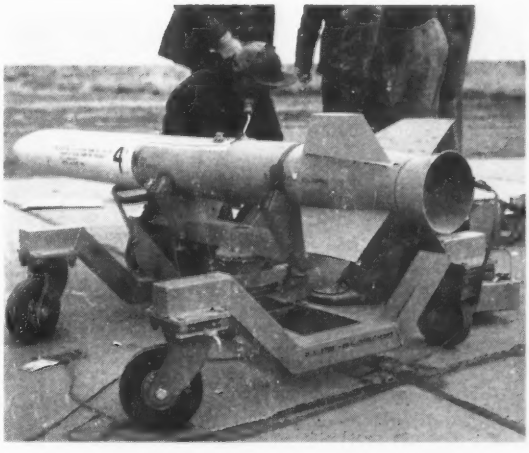
AF Missile Development Center:

Proving ground for ideas

THE Air Force Missile Development Center, sprawling over 2500 square miles of New Mexico's vast Tularosa Basin, is the heart of the missile age from the standpoint of the development and testing of guided missiles for Air Force use. The name—AF Missile Development Center—may be new to a large number of readers, since before September the base was known as the Holloman Air Development Center. Recognition of the Center's expanded mission, which now includes the development of missile components and subsystems, is reflected in its new name.

One of 10 centers operated by the Air Research and Development Command, the Missile Development Center is located on Holloman AF Base, a former wartime airfield and bombing range. Since the dawn of the missile era, AFMDC has provided facilities for the development and testing of missiles, rockets, instruments and related equipment.

About 7000 persons are employed at the Center,

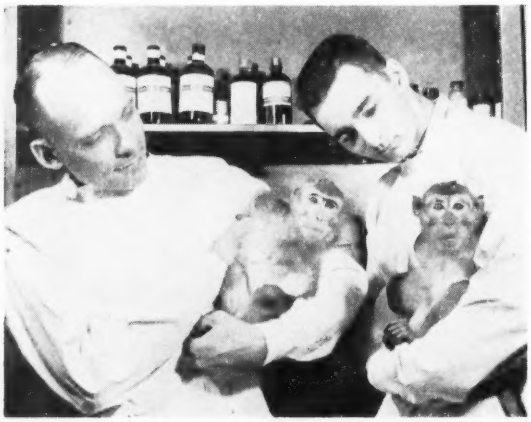


Rockaire upper air research rocket is prepared for test. With its payload of recording instruments, the slim 10-ft vehicle is launched into the stratosphere from a jet aircraft climbing straight up.

Sled used for calibrating AFMDC's high-speed track grins at the inviting waters of the braking pool.

more than 4600 of them civilian employees of the 35 companies that maintain offices there. Also included among the civilians are large numbers of Civil Service employees.

Frequently, AFMDC is host to upper air scientists who use its facilities to send rockets into the stratosphere and beyond. It is also home to the Air Force's Aero-Medical Field Laboratory, famed for its basic research on acceleration and deceleration with powerful rocket sleds, as well as for its Space Biology Branch, which has sent animals and plants into the stratosphere to study cosmic radiation effects. Recently, Maj. David G. Simons, Chief of the Branch, made a record ascent to more than 100,000 ft in a balloon.



Monkeys that survived a balloon trip 18 miles up are held by Maj. David G. Simons (left), Chief of Space Biology at the Aero-Medical Field Laboratory, and a technician.

The Center boasts one of the best high-speed rocket sled track facilities in the country. These facilities are in constant use for pre-flight testing and analysis of missile and aircraft components. The track, when completed by May of next year, will be seven miles in length, the longest in this country and probably in the world.

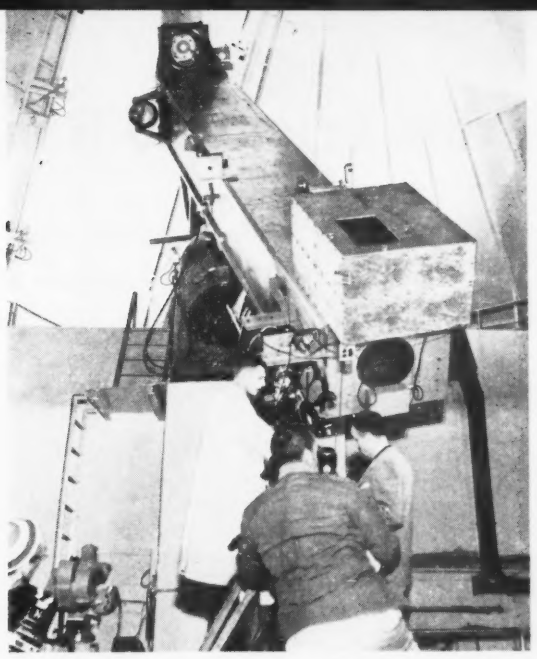
Looking to the future, facilities to house one of the most extensive data processing centers in the western world are now under construction at the Center. This facility will provide complete analyses and evaluation of missile-firing data, including "real time" flight data for actual missile control.

For rocket and missile firings, the AFMDC range is coupled with that of White Sands Proving Ground directly to the south, providing almost 5000 square miles of test area. The Integrated Range is about 100 miles long and 40 miles wide, and is bordered by the San Andres and Sacramento Mountains that form its natural boundaries. Firings are coordinated by a committee made up of representatives of all three services.

Majority Live in Nearby Towns

Many of AFMDC's civilians and their dependents live in housing on the base, but the majority live in nearby cities and towns. Notable among these is Alamogordo, a fast-growing progressive city of 19,000 people located 10 miles east of the base. Abundant outdoor recreational facilities in the area,

Graceful Aerobee-Hi is fitted tenderly into tower groove before firing.



Coronograph at 9200-ft Sacramento Peak Observatory, supported by AFMDC, is examined by visitors.

plus a sunny, dry climate, make living and working at AFMDC an appealing experience.

Development test work at AFMDC has involved such missiles as the air-to-surface Rascal, the air-to-air Falcons and the surface-to-surface Matador.

Aerobee-Hi rockets permit upper-air physicists at the base to search the heavens at altitudes of 100 miles and more. Occasionally, mice and monkeys take the place of the 150-lb payload allotment usually used for research instruments. Aerobees are launched from a special tower in the northern part of the base. Rising 152 ft, the tower can be tilted 4 deg North, 3 deg East or 2.5 deg West to insure safety of the base from unguided vehicles.

Balloons Often Used with Rockets

Balloons are frequently used with sounding rockets, and the huge polyethylene bags, some inflating to a diameter of 200 ft, can often be seen rising above the base. Some have gondolas capable of carrying loads of more than 1000 lb, and can keep instruments aloft much longer than rockets, although at much lower altitudes.

The AFMDC's famous rocket sleds are accelerated to supersonic speeds by as much as 27,000 lb of thrust and then are stopped abruptly by means of a water brake, thus allowing many of the forces acting on missiles and men to be simulated on the test track. In addition, the base's 4092-ft elevation makes it possible to simulate bailout from manned aircraft at speeds up to 1800 mph at an altitude of 40,000 ft.

Hypersonic test vehicle shoots toward 5000 mph speeds in 2 sec on first of two solid rocket motors.

From bricks to Rascals

The complete story of air-to-surface missiles, from their birth to today's efficient weapon systems, capable of pinpointing and destroying targets as much as 100 miles from attacking aircraft

By Frederick I. Ordway III

GENERAL ASTRONAUTICS CORP., HUNTSVILLE, ALA.

IN JULY 1942, a U. S. Navy Catalina flying boat dropped an antisubmarine retro-bomb and thereby became the first American aircraft to fire a rocket while in flight. Strange as it may seem, the missile's rocket motor fired rearward so that the forward motion imparted by the airplane would be canceled and the bomb would fall vertically.

But it wasn't long thereafter that forward-firing aircraft rockets appeared. In fact, they sank their first submarine in January 1944. Developed by the British, the 3.5-incher soon became a reliable wartime weapon on many fronts. Interestingly enough, the Russians led off in this field, using aircraft rockets as early as 1942 against German Tanks.

AIR-TO-SURFACE WARFARE

The history of tactical military operations has been closely associated with height: He who had the commanding position, other things being equal, stood an excellent chance of winning the battle. Soldiers have always sought the opportunity to throw things *down* on the enemy.

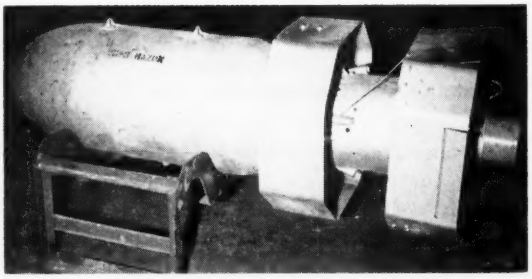
With the introduction of the airplane, it was inevitable that someone would want to drop something from it. There are tales of World War I pilots who started off by tossing bricks on troops below. It was not long before these bricks became bombs. Bricks or bombs, the aviator soon became frustrated, for many missed the target and landed harmlessly in some cow pasture.

Ordnance experts took the next logical step forward by modifying the bomb so that its flight path could be controlled after it left the airplane. Some bombs were attached to wings and other aerodynamic surfaces, and allowed to enter a controlled glide to the target. Others were free-falling, often guided only in azimuth. Still others were rocket powered.

Each development offered improvements. Guided free-falling bombs increased the possibility of hitting the target. The guided glide bomb not only increased accuracy, but also enabled bombing aircraft to hit targets from beyond the reach of enemy anti-aircraft artillery. And with power, in the form of a rocket or jet motor, added to the bomb, this advantage grew even more.

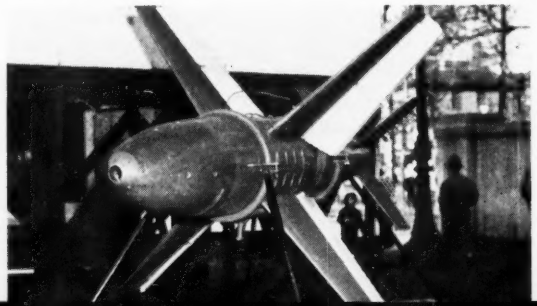
Thus, the air-to-surface guided missile evolved. And, in World War II, the first successful ASM made its appearance. It was the German armor-piercing Fritz-X, which, though free-falling, was radio-guided. Before long, air-to-surface weapons were to become a major factor in military planning.

VERTICAL BOMBS



VB-3 RAZON. Radio set and guiding flare are in the tail.

VB-10. Nose camera put televised picture on bombardier's screen.



However, American progress was also rapid. The 4.5-incher, the famed HVAR, Tiny Tim and other rockets quickly followed one another into operational use, raising havoc with the enemy in both the European and Pacific theaters.

Among the first American air-to-surface missiles (ASM's) to see general service was the Army Air Corps' GB-1 general-purpose glide bomb. Outfitted with a monoplane airframe and preset autopilot, it first saw service in May 1944. A later version, the GB-4, also saw action. This type had a television camera and a radio transmitter. Observing the target by means of television, the bombardier would bring the weapon in for the kill through a radio command link.

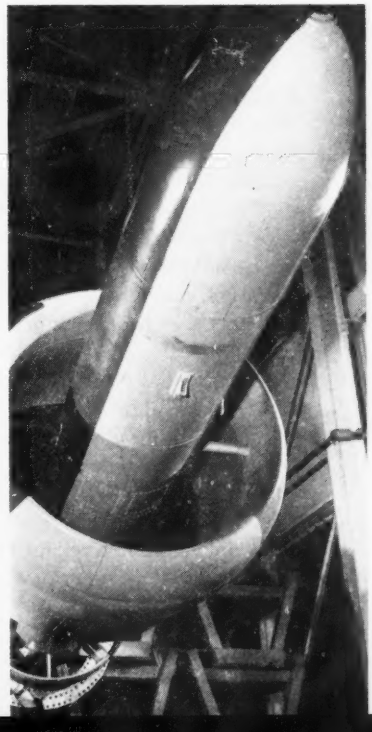
Navy Claims First Automatic Missile

The Navy considers the Bat, a monowing radar homing glider developed for use against the Japanese, to be the world's first fully automatic guided missile used in combat operations. Other Navy missiles were the Pelican, an earlier development, and the Robin, which had a television eye.

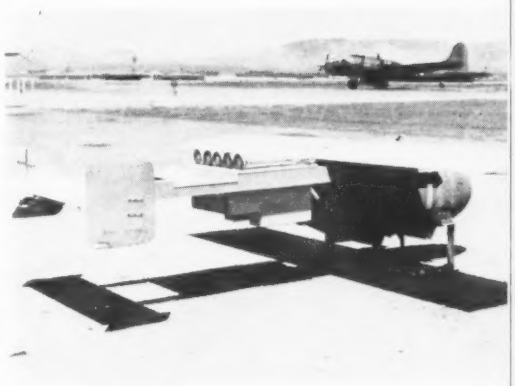
All these missiles were classed as glide bombs (GB). They employed both surface controls for guidance and air foils for lift. These provided increased accuracy and range.

The Azon, Razon and Tarzon all belonged to the

TARZON (left), a 12,000-lb radio-controlled bomb, was an early Bell development. ROC (right), a Douglas 1000-pounder, had two O-shaped shrouds.

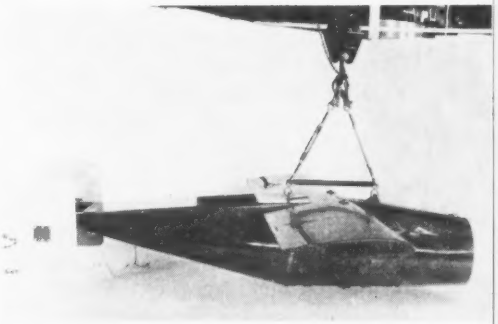


GLIDE BOMBS



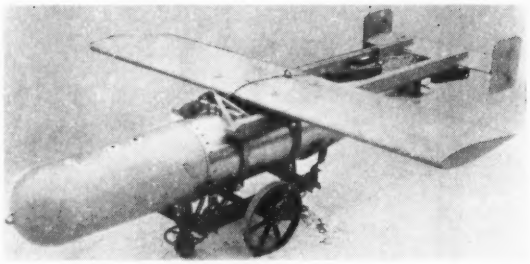
GB-8. A 2000-lb bomb fitted with a special airframe, it was radio-controlled.

GB-12. This glide bomb featured television control.



GB-14. A later series, it used infrared target-seeking devices.

MODIFIED TORPEDOES



GLIDER TORPEDO. A standard aerial torpedo fitted with a glider frame, GT had gyro-controlled tail surfaces.

PETREL. Also basically an aerial torpedo, it is powered by a turbojet engine.

JET BOMB

JB-2. This bomb was an adaptation of Germany's V-1 pulsejet.

vertical bomb (VB) category, and were either guided in azimuth alone, or in both azimuth and range (horizontal distance). The VB-2 Azon weighed only 1000 lb, while Tarzon, justifying its name, was a 12,000-pounder. Most of the VB weapons carried high-intensity flares in their tails to aid the bombardier in his guiding function. Roc, a later model, was commanded by television, which relayed incoming radio impulses to a servo system actuating a tail steering ring.

The JB series of jet bombs offered the advantage of self-contained power units, which increased both the range and velocity of the missile. The best known was the JB-2, an air-launched version of the German V-1 "buzz bomb." The Navy had several versions of a solid rocket propelled bomb called the Gargoyle, while another Navy weapon, the Gorgon KU3N-1, was extensively tested during the early postwar years. The last Gorgon ASM was model V, the XASM-N-5 glide missile.

These developments enhanced the advantages of the airborne attacker and gave new breadth to air-to-surface warfare. Yet a number of weaknesses soon became apparent as intercepter speeds increased, ground missile defenses improved and electronic jamming techniques matured.

In the typical guided bomb of 10 years ago, signals would be sent from the bomb and fed into a computer installed within the airplane. Relevant information on the bomb's position, altitude and motion could be ascertained, allowing proper corrective signals to be transmitted. Often, television viewers would be used.

Today, systems such as these could easily be jammed. In addition, these slow-moving glide bombs could probably be intercepted.

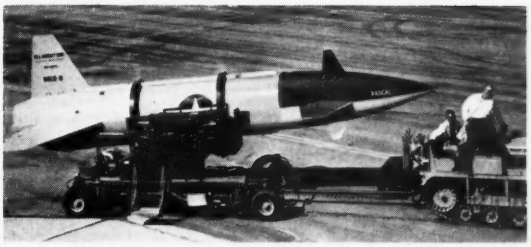
Guidance Systems Improve

To get around the limitation of radio and radar systems, infrared guidance has been tried in the ASM field. One of the earliest examples was the Felix VB-6 controlled bomb. Heat seekers of this sort home on the infrared radiation produced by the target, and jamming is next to impossible.

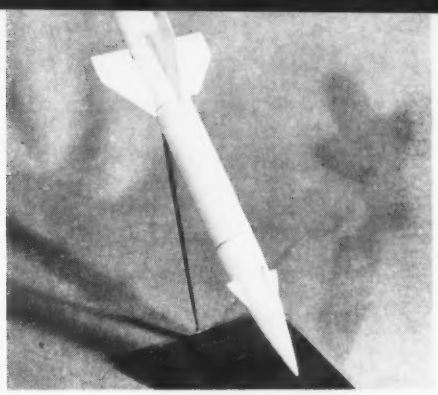
An inertial system, wherein gyroscopes and integrating accelerometers provide information on changing spatial positions and motions, can also be used for missiles in the air-to-surface category. Servomechanisms adjust control surfaces in response to command, thereby eliminating errors that creep in along the flight path.

Tactical situation, range and weather permitting, visual line-of-sight tracking of the target can also be efficient. It is superior to radar when radar is

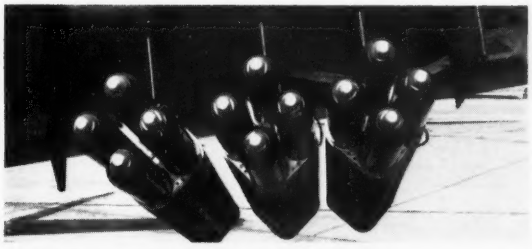
MODERN MISSILES

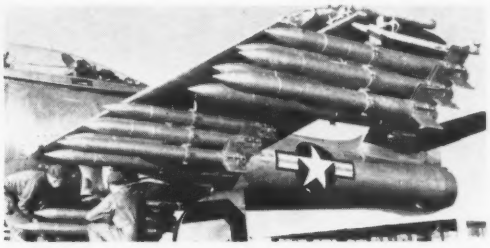


RASCAL. A rocket-powered guided bomb, Bell missile has a 100-mile range.



BULLPUP. A Martin solid propellant rocket, it is designed for use in close air support.





FIVE-INCHERS. Zuni (left) is taking over where HVAR (right) left off.

unable to discriminate between the desired target and the undesired ones, as would be the case when the target is a tank rather than trucks ahead or behind it.

An optical beam-riding system is often used. Here, the radar antenna and beam are tied in to the optical tracker. It is also possible to track a missile-mounted beacon by means of radar carried in the attacking airplane.

In the optical system, the missile would be launched and then acquired by the tracking radar. If it is optically tracked at the same time, a computer would be required to interpret data flowing from the missile, and relate them to target position.

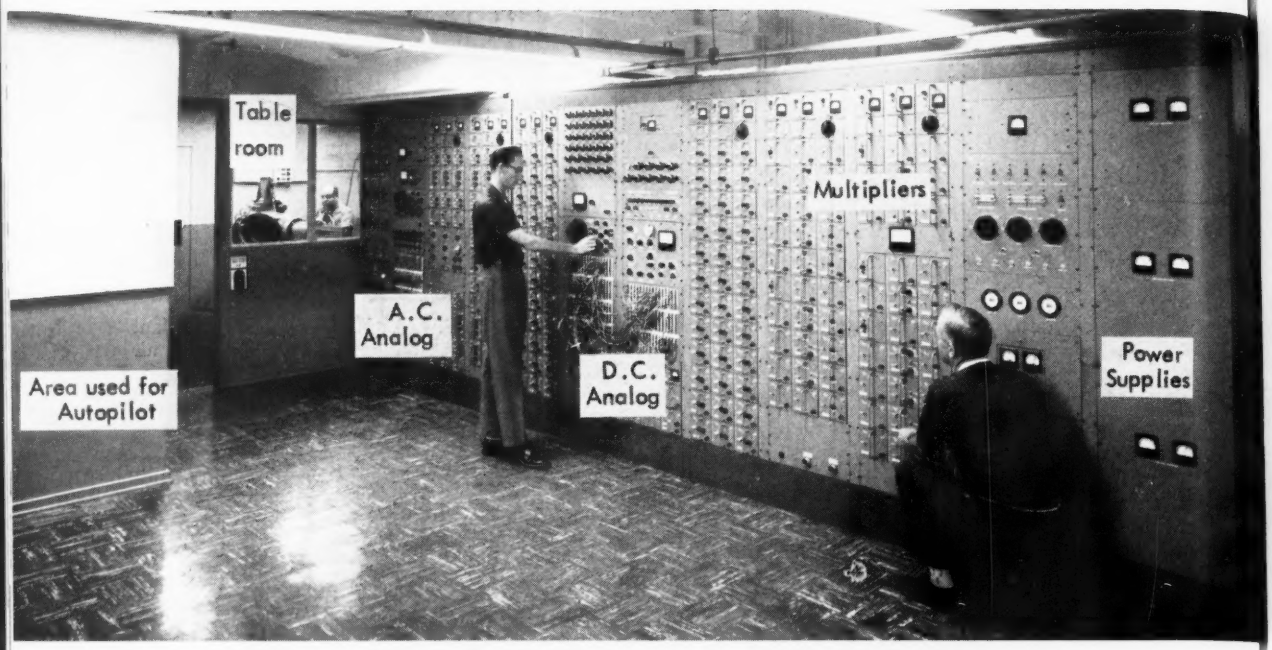
The type of missile to be used in a given tactical situation depends on a number of things, among them guidance, target, type of aircraft, warhead and countermeasures.

Warheads and targets are closely tied together. If the target is small—an armored truck, for example—and the guidance system highly accurate, a small missile with a shaped charge would probably suffice. On the other hand, strategic, behind-the-lines targets would probably require an atomic warhead placed in a missile like the Rascal. A warhead of this type would produce enormous blast effects, as well as thermal radiation and radiological damage. It is not likely that highly complex, costly weapon systems like Rascal would be used to carry a conventional chemical high explosive charge, especially if the guidance was not extremely accurate.

On the tactical front, fragmentation warheads would be useful against troops in the field, concentrations of nonarmored vehicles, supplies and ammunition, and aircraft on the runway. The blast effects of high explosives would destroy buildings and other structures, while, as noted above, a shaped charge would be applicable against small, tough targets such as armored vehicles or even pillboxes. We may some day find missiles carrying nerve gas warheads, bacteriological payloads and as yet unknown explosive materials. The characteristics of the warhead and of the target will dictate the fuse to be employed.

ASM's Yield Top Position

The present U. S. air-to-surface missile arsenal does not, on the surface, at least, seem particularly spectacular. While ASM's headed our missile arsenal during World War II, today they appear to be somewhat behind the times. Surface-to-surface, surface-to-air and air-to-air missiles are much more abundant, and certainly figure more prominently in the news. Never- (CONTINUED ON PAGE 79)



Autonetics flight simulation facility at Downey, Calif. Flight table itself is in the room at left center.

"Flying" missiles on the ground

Flight simulation table, coupled with analog computer, provides a means for checking out components prior to actual flight testing

By Eric Burgess

TESTING of missiles and aircraft navigation systems would be fabulously expensive if actual flight tests were necessary to prove out each and every item of equipment. In the case of a missile in the development stage, for example, failure in a flight test might lead to invalidation or complete loss of data concerning expensive hardware.

So, in order to determine such things as stability and control characteristics of missiles without subjecting the vehicles to actual flight tests, scientists resort to the process of flight simulation on the ground, using the Newtonian equations of motion. Since there are no general solutions to these equations, unless restricted cases are considered, a computer has to be used to give meaningful results.

In recent years, various kinds of analog computers have been designed to ease the research burden necessary to produce reliable weapon systems. In computers of this type, physical quantities are represented by electrical analogs. Thus the rotation of a shaft in a missile might operate a potentiometer, the voltage output of which would be an electrical analog of the angular position of the shaft.

In a similar manner, voltages can represent the speed of a missile, its orientation in space, aerodynamic constants and variables, characteristics of the atmosphere and the earth's gravitational field, and the operation of the power plant propelling the vehicle.

All the factors which govern the flight of a missile can thus be simulated and related mathematically within the computer to allow for dependencies of one upon the others. This is done by programming the computer to process the electrical analogs in accordance with the equations of motion.

Such things as the flight path of a missile, effects of power plant malfunctions, atmospheric factors and failure of individual components, can all be checked out on the computer without flight testing a single vehicle. Moreover, through use of an analog computer, an actual piece of hardware from a missile can be plugged into the system and tested as though it were part of a real missile.

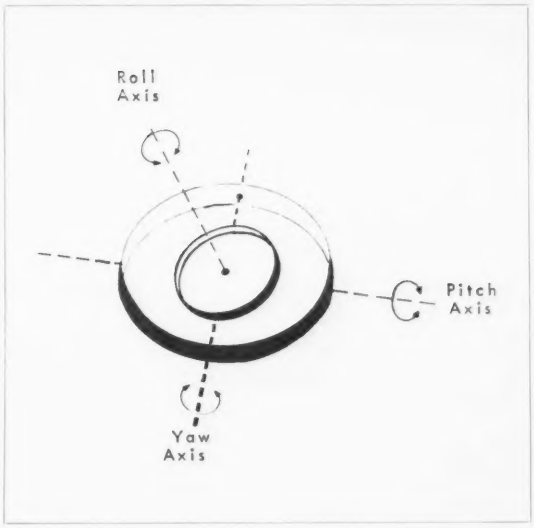
Tabled for Flight

In simulated flights, it is often necessary that a piece of hardware, such as a guidance system, be subjected to the orientations which would be experienced in flight. In addition, it is also important to be able to position navigational instruments as they would be in flight in order to ascertain how they behave and whether or not they are sending the correct signals to the controls for maintenance of a desired flight path.

Flight simulation tables have been developed toward this end. Problems encountered in their development have centered primarily on obtaining three degrees of freedom without vibration, and with assuring quick response to control signals. Thus, vibration has to be prevented by using massive mountings for the table, and these usually lead to a slow response.

The Bendix flight simulator table overcomes these problems. One of these tables is now in use at the Flight Simulation Facility of the Preliminary Engineering Section, Autonetics Div. of North American Aviation, at Downey, Calif. The table is an outgrowth of one at the Massachusetts Institute of Technology, and considerable work has been done to develop quick-acting servos and eliminate vibration. To achieve this, the table has been made very massive and weighs over 7000 lb. However, its response time is remarkably good and time lag has been minimized.

The Bendix unit is a (CONTINUED ON PAGE 80)



Simplified diagram of Bendix flight simulation table, showing how gimbals give it motion in pitch, roll and yaw.

Preparing the table for test of gyros in missile navigation system. Large box on table contains attitude gyro, smaller box a rate gyro. Projecting arm at right is housing for slip-ring electrical pick-offs and below it is junction box for computer connections.

Synthetic atmospheres for space ships

Providing adequate air supply system and livable temperatures is no mean problem . . . Here's a look at how this might be done

By John Gustavson

UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF.

PILOTS of high altitude aircraft are today getting their first taste of what it's like to fly in space. Requirements for human survival, such as oxygen for respiration, are as rigid in piloted rocket aircraft as they would be in true interplanetary space vehicles. There is, of course, one important difference —flight duration. Today's piloted aircraft are capable of remaining in the extra-atmospheric region for less than an hour, while the space vehicle designed for circumnavigation of the moon must provide for survival of the crew over a much longer period.

The first problem, then, will be development of an air supply system that will provide a crew of four or five persons with an adequate atmosphere for, let's say, a minimum of 10 days. Such a system will have to meet a number of basic requirements.

Cool and Comfortable

Temperature control, for example, will be very important. The combined problem of space confinement and, perhaps, severe psychological stress will be eased only by carefully designed furnishings and a conditioned atmosphere.

Man is at ease physically only between 70 and 90 F. Closely related to the temperature of the air is the humidity. It is already known that humans can endure higher temperatures if the relative humidity is kept low, and also that low temperatures are much more easily tolerated in a "dry," rather than a "wet," climate. In the sealed space cabin, however, where utmost physical comfort is mandatory, the temperature must lie within the stipulated range and the humidity must be stabilized at about 40 per cent.

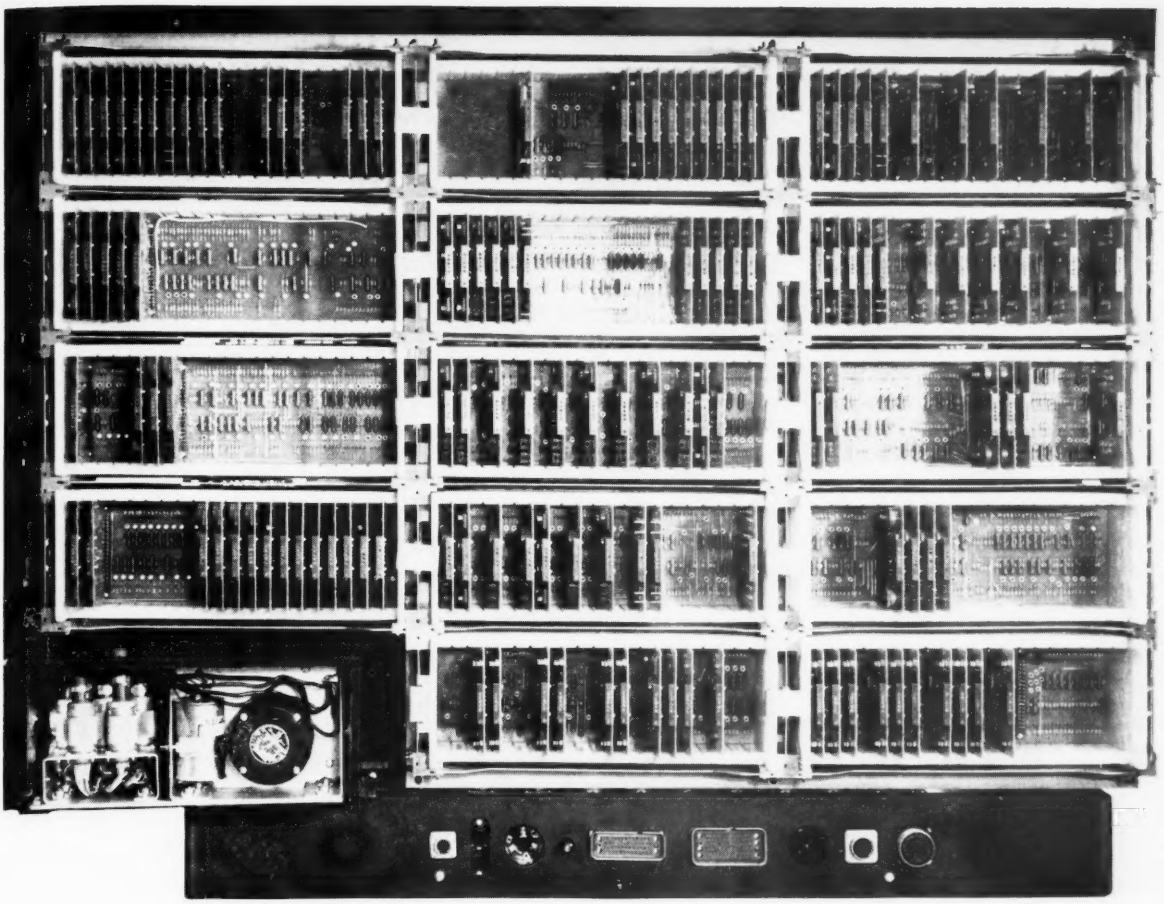
The pressure of the enclosed atmosphere is a compromise between human requirements and structural considerations. (CONTINUED ON PAGE 62)

Space Ship Hot Spots

Source	Amount
Sun (radiative heating)	445 Btu/ft² hr
Electronic equipment	15 Btu/lb hr
Heat generated per crew member	470 Btu/man hr
Electric lighting	3.4 Btu/watt hr

Toxicity Levels for Prolonged Exposure

Gas	Safety limit (parts per million)
Oxygen	800,000
Carbon dioxide	5,000
Gasoline	500
Ammonia	100
Carbon monoxide	100
Hydrogen sulphide	20
Ozone	1
Fluorine	0.3
Mercury	0.1



The Role of
PRODUCT ENGINEERING
in Systems Work

It has become characteristic of modern weapons systems that they are required to operate under severe environmental conditions, as well as to meet stringent weight and space limitations. Moreover, the complexity of many of these systems poses additional difficult reliability problems, while at the same time the increasingly critical consequences that depend on the proper functioning of the typical system logically call for a *higher* degree of reliability than previously achieved. The same is true of certain electronic systems for industrial applications, such as the Ramo-Wooldridge digital control computer, some of whose design features are shown above.

Meeting all of these requirements is in large part the responsibility of product engineering. Generally speaking, product engineering starts with a system or subsystem at the breadboard stage and transforms it into the final product, which in addition to meeting all of the requirements previously stated, must be practical to manufacture and to maintain. Such creative productizing requires the development of ingenious mechanical design features, a thorough knowledge of circuit design and component reliability, and a broad familiarity with materials and manufacturing processes.

At Ramo-Wooldridge, the product engineer is an essential member of the research and development team which has the full responsibility for creating new systems, from the initial theoretical studies on into the manufacturing stage. Engineers experienced in product engineering are invited to explore the variety of openings which exist at Ramo-Wooldridge in such fields as airborne electronic and control systems, communications and navigation systems, digital computers and control systems, and electronic instrumentation and test equipment.

The Ramo-Wooldridge Corporation

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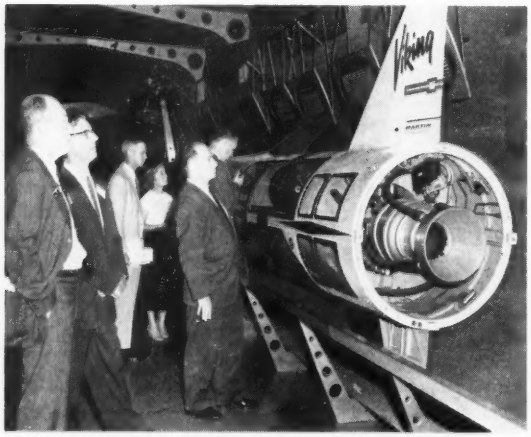
Joseph Kaplan (left), Chairman, USNC-IGY, and Richard W. Porter (right), Chairman of the U. S. Technical Panel on the Earth Satellite Program, compare notes before the meeting with Joseph Chamberlain, Hayden Planetarium Director.

Spotlight on satellites

Project Vanguard, rockets get star billing at Hayden Planetarium's "Earth, Air and Space" symposium . . . Kaplan, Porter among speakers

ROCKETS and the earth satellite program stole the spotlight at the American Museum-Hayden Planetarium's recent "Earth, Air and Space" symposium in New York. An overflow crowd of more than 650 attended the all-day session, highlighted by the presentation of six papers dealing with various aspects of the International Geophysical Year.

Richard W. Porter, consultant to General Electric Co. and Chairman of the Technical Panel on the Earth Satellite Program, U. S. National Committee for the IGY, took the opportunity to announce that the baby test satellites which will ride in each of the last four Vanguard test vehicles will contain two types of radio transmitters, one powered by a chemical battery and the other by six solar cells mounted on the skin of the tiny balls.



Visitors were fascinated by the cutaway Viking rocket, part of the exhibit held in conjunction with the symposium.

These transmitters, located in the center and on the skin respectively, should permit measurement of the temperature at these locations to within 5 C, Dr. Porter, a former President of the AMERICAN ROCKET SOCIETY, said.

The interior transmitter will be powered by a battery that operates between 60 and 80 C to send out a signal at 108 mc-4 kc. The exterior transmitter for which the solar cells are expected to provide power at temperatures all the way down to —20 C, will send at 108.03 mc-4 kc. For each degree of temperature change from the ambient, the signal frequency will change about 100 cycles, Dr. Porter explained.

Each of the baby satellites will be 4.6 in. in diam and weigh about 4 lb. They will take the place of the full-sized satellite in the test vehicles for the purpose of evaluating the vehicle's effectiveness. While there is "a theoretic possibility" that they will become satellites, the chances are not regarded as too good, especially in the first few tries, because of the extra weight the vehicle will carry in test instrumentation.

Joseph Kaplan, professor of physics at the University of California and USNC-IGY Chairman, kicked off the meeting with a survey of the work to be accomplished during the 18-month international scientific effort. Papers were also delivered by Walter O. Roberts, Director of the High Altitude Observatory, Boulder, (CONTINUED ON PAGE 79)

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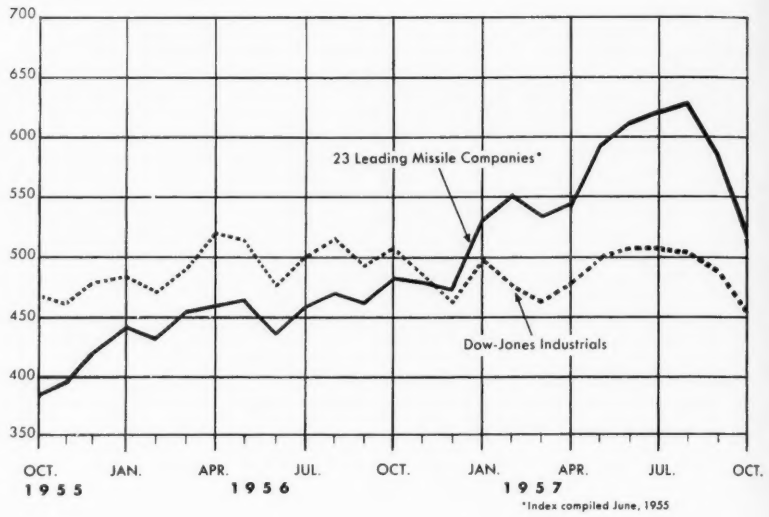
General Mills

missile market

Financial news of the rocket and guided missile industry

BY ROBERT KENMORE

THE MARKET AT A GLANCE



	October 1957	September 1957	% Change	October 1956	% Change
Dow-Jones Industrials	457	484	— 5.9	509	—11.4
23 Missile Companies	518	583	—12.5	481	— 7.7

WHILE the market as a whole continued to slide off from July peaks, the missile index declined a sharp 12.5 per cent, bringing it down to last January levels, as market men scratched their heads and sought reasons for the plunge. Although the biggest declines came in aircrafts, component manufacturers shared in the general September dip.

While the facts fail to reveal any real causes for the plunge, there can be little doubt that market psychology was a potent factor. It's true that budget cuts have been making headlines in recent weeks, but this fails to explain why stocks of companies whose missile programs are being pushed hard, rather than stretched out or cut, have dropped just as much as any others. If anything, Russia's successful "Sputnik" and successful ICBM firing point up the fact the outlook is for a heavier-than-ever accent on missiles in the U. S. military program.

To the investor, however, the current market situation is worthy of study. Market psychology should not, of course, be disregarded, since its power as a price determinant is well known. What should be considered, however, is the fact that market psychology can only affect the price of a security for a given period of time, that values are set by earnings and dividends, and that price and value will inevitably adjust to one another, regardless of any other factors.

Still Seems Good Policy

Translated into action, this means that *informed* buying for long-term appreciation still seems like a good policy, and now more so than ever. The key word, of course, is "informed." This is not the time to buy the market or the averages, a policy which would have been effective almost any time in the last eight years, but rather a time of careful selection. Just as it is dangerous to be an out-and-out bull, it is shortsighted to be an unqualified bear. You cannot reduce your long position in the stock market without increasing your long position in money, and money has been a spectacularly poor investment in the history of any country.

To sum up, then, and fully realizing that investors worry about lower government expenditures, possible cuts in business investment, tight money, international tensions, manufacturing output in excess of new orders, the squeeze in profits, divided uncertainties, the big drop in non-ferrous metals prices and the fear of a business slump, careful selection of securities in the missiles and rocket field continues to offer a tremendous opportunity for long-term capital appreciation.

Last month we started a discussion of the leaders in the rocket and guided missile field with an examination of Aerojet-General and Marquardt Aircraft. Before rounding out this group with an evaluation of Reaction Motors and Ramo-Wooldridge, some general comments should be made about the group as a whole. In general, the following points must be kept in mind when investing in such companies:

1. All of them have the backing of much bigger and better financed enterprises. This is probably the most important factor in their selection and success potential. Companies like General Tire, Olin Mathieson and Thompson Products have forward-looking managements which have invested large sums in these rocket and guided missile companies, and will do everything in their power to make their investments pay off. As full active partners with the individual investor, these corporate giants provide an invaluable built-in safety factor, giving these four companies a decisive edge in future competition for their share in the growing rocket-missiles industry.

2. Many years will pass before cash dividends of any proportion will be paid to stockholders. These companies are young and in a period of dynamic growth and must reinvest virtually all of their earnings in expansion.

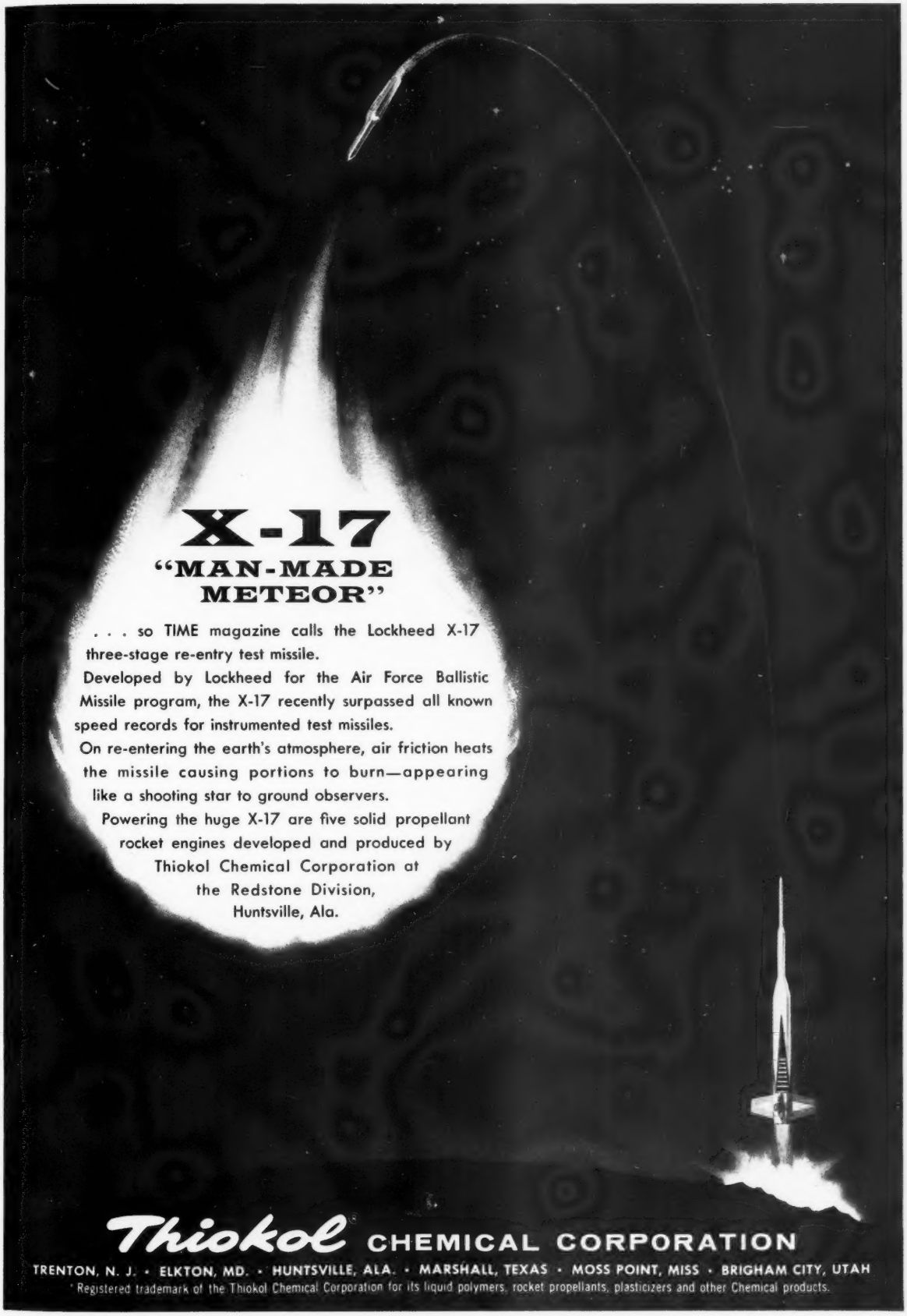
3. Market action of these companies may be highly erratic. These securities should, therefore, more than any others, be bought for the long pull. An interim decline should not effect an investment decision but should rather be used as an opportunity to increase positions and dollar cost averaging.

4. Stock splits and stock dividends will occur with above-average frequency.

5. Price-earnings ratios will be consistently higher than for more prosaic investments.

These factors indicate that investment in these companies will not be everybody's cup of tea. Consequently, investment objectives should be care-

(CONTINUED ON PAGE 81)


X-17
"MAN-MADE METEOR"
. . . so TIME magazine calls the Lockheed X-17 three-stage re-entry test missile.
Developed by Lockheed for the Air Force Ballistic Missile program, the X-17 recently surpassed all known speed records for instrumented test missiles.
On re-entering the earth's atmosphere, air friction heats the missile causing portions to burn—appearing like a shooting star to ground observers.
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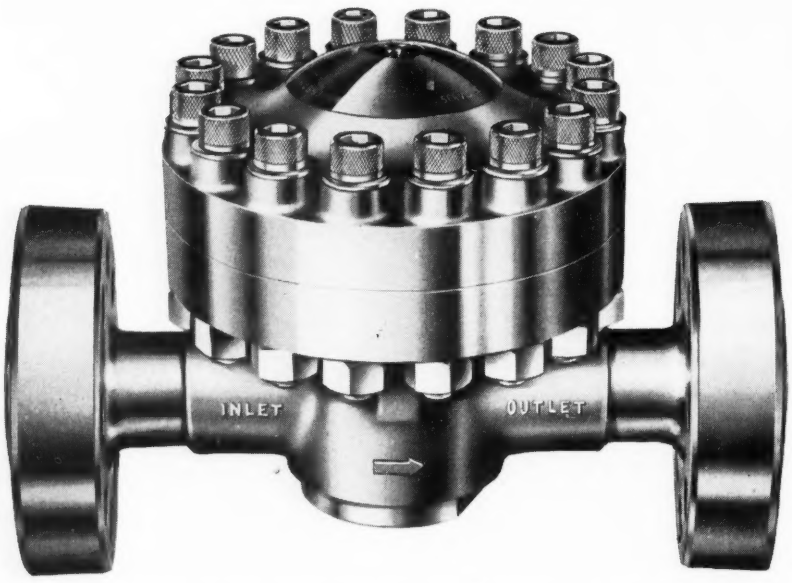

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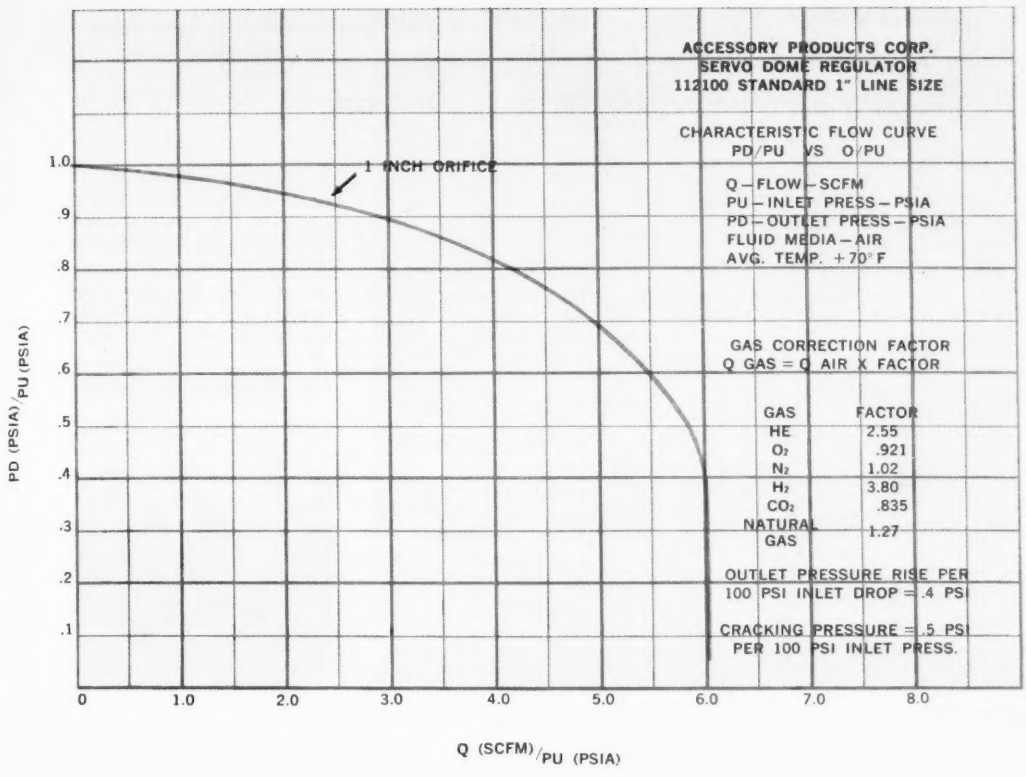

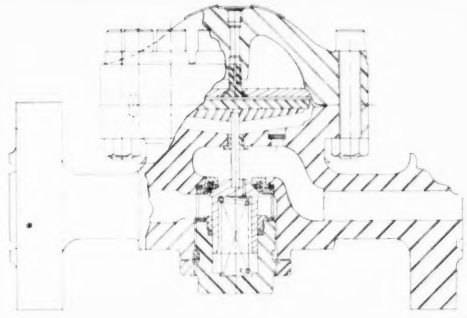

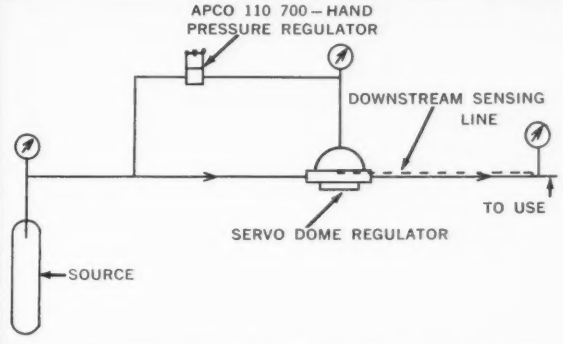

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ARS news

Annual Meeting to Open Dec. 2 in New York

The 12th Annual Meeting of the AMERICAN ROCKET SOCIETY will get under way Dec. 2 with the opening of a special Rocket and Satellite Exhibit at the New York Coliseum, and will run through Dec. 6, winding up with the first ARS Eastern Regional Student Conference.

The meeting, to be held at the Hotel Statler, is shaping up as the "biggest and best ever organized by the Society," according to National Program Chairman Kurt Stehling. It includes, in addition to the exhibit already mentioned, a full schedule of technical sessions, luncheon addresses by two prominent speakers, a Section Delegates Conference, a special film night, and the annual Honors Night Dinner.

The 12 technical sessions, organized for the first time by the seven ARS Technical Committees established early this year, reflect the full range of the Society's interests. Dozens of the country's top centers of rocket and guided missile activity have been combed for outstanding papers covering such areas as combustion, solid rockets, liquid rockets, propellants, ramjets, space law and sociology, instrumentation and guidance, human factors and space flight.

In addition, the program includes the first classified session ever offered at a national ARS meeting. The subject is "The State of the Art of Liquid Rocket Combustion and Propellants."

Two distinguished speakers will make their first appearances before a national ARS audience at the meeting. They are Brig. Gen. H. F. Gregory, Chief of the Air Force Office of Scientific Research, and William M. Holaday, Special Assistant to the Secretary of Defense for Guided Missiles.

As an extra added attraction, the American Society of Mechanical Engineers will be holding its annual meeting in the Statler at the same time, so that those attending the ARS meeting will be able to choose from among more than 100 ASME sessions as well.

Registration for the ARS meeting promises to surpass the record 1400 that marked the April meeting in Washington earlier this year.

Almost the entire 18th floor of the Hotel Statler will be taken over by the Society for the meeting, with registration, publications and meeting rooms all within easy walking distance.

The preliminary program is as follows:

Monday, December 2

Rocket and Satellite Exhibit opens at Coliseum

Tuesday, December 3

Combustion Session
Solid Rockets Session
Propellants Session
Ramjets Session

Wednesday, December 4

Space Law and Sociology Session
Instrumentation Session
New York Section Luncheon, featuring an address by Brig. Gen. H. F. Gregory, Head of the Air Force Office of Scientific Research
Liquid Rockets Session
Human Factors Session
Annual Business Meeting
New York Section Film Night, featuring first films on Vanguard tests

Thursday, December 5

Space Flight Symposium
Guidance Session
Section Delegates Luncheon
Classified Session on State of the Art of Liquid Rocket Combustion and Propellants
Guidance Session
First ARS Section Delegates Conference
Annual Honors Night Dinner

Friday, December 6

First ARS Eastern Regional Student Conference with Polytechnic Institute of Brooklyn Chapter serving as host
Presentation of student papers
Conference Luncheon, to be addressed by Joseph Kaplan, Chairman of the U. S. National Committee for IGY
IGY Forum, panel for students moderated by Kurt Stehling

The complete program for the meeting will be printed in the December Annual Meeting Issue of ASTRONAUTICS.

Jacobson to Represent ASME on ARS Board

Eugene W. Jacobson, Technical Director of the American Society of Mechanical Engineers and chief design engineer, Design Section, Executive Branch of Gulf Research and Development Co., will represent ASME on the ARS Board of Directors as part of a move to improve working relationships between the two groups.

As noted last month, Robertson Youngquist of Reaction Motors will fill the corresponding role on ASME's Board of Technology for ARS.

Each will take part in deliberations but will not vote.

ARS Members in the Field

Sacramento Section officers, shown on outstanding field trip to Travis AFB are (kneeling, left to right) E. D. Haley, board member, and Wayne H. Fenton, secretary, and (standing, left to right) W. D. Cavender, board member, Clair M. Beighley, vice-president, and H. J. York and J. C. Moise, board members.

5 More Firms Become ARS Corporate Members

Five additional companies active in the rocket or jet propulsion fields have become corporate members of the AMERICAN ROCKET SOCIETY. They are:

Cleveland Pneumatic Tool Co., Cleveland, Ohio, whose Special Products Div. produces missile ground support equipment and whose National Water Lift Div. makes missile control systems and components.

Representing the company in ARS activities will be Clifford Willis, vice-president and general manager, Water Lift Div.; Joseph J. Jerger, director of engineering; T. G. Hearn, director of marketing; John J. Brogan, general sales manager; and Wallace Hamilton, chief engineer, Special Products Div.

Radiation, Inc., Melbourne, Fla., active in the design and development of electronic equipment and systems for instrumentation, guidance, control and testing of missiles, including com-

plete telemetry, data processing and checkout systems.

Named to represent the company in the ARS are Lawrence Gardenhire, technical consultant; George S. Shaw, vice-president; John W. Downs, director, RF Systems Div.; Arthur R. Beach, technical advisor; and Conrad H. Hoeppner, director of research.

Reeves Instrument Corp., Garden City, N. Y., active in the fields of missile instrumentation and guidance, radar systems, analog computers and inertial guidance.

Representing the company in the ARS will be R. D. McCoy, vice-president; E. K. Stodola, director of engineering liaison; S. Godet, director of research; J. F. Lepre, director of industrial relations; and J. J. Ryman, systems sales manager.

American Potash & Chemical Corp., Los Angeles, Calif., active in the high-energy propellant field.

Representing the firm in ARS activities are George S. Wheaton, vice-president; Herbert W. Yeagley, Washington representative; E. H. Kent, director of engineering, National Northern Corp.; Samuel J. Porter, vice-president and general manager, National Northern Corp.; and George A. Schnier, manager, chemical fuel sales.

Eastman Kodak Co. (Apparatus and Optical Div. and Navy Ordnance Div.), Rochester, N. Y., producers of scoring devices, missile instrumentation, mechanical and electronic fuzing, power supplies, infrared components and systems, electro-mechanical devices for missile warhead and propulsion safety, and beacons and telemeters.

Representing the company in the ARS will be Newton B. Green, general manager, Apparatus and Optical Div.; Fordyce E. Tuttle, director, Apparatus Research and Development and Navy Ordnance Divs.; William B. Forman, associate director, Apparatus Research and Development; E. H. McLaughlin, superintendent, Research, Development and Engineering, Navy Ordnance Div.; and George S. Gunnison, supervising development engineer.

SECTION NOTES

Antelope Valley: About 85 members of the Antelope Valley Section got a real treat in September when they were guests of the U. S. Navy aboard our first guided missile ship, the "USS Norton Sound." The program included an eight-hour trip into the Pacific, missile firings, indoctrination on the Navy missile program, an inspection of the entire ship and observation of officers and men in the performance of shipboard duties, and a pleasant lunch aboard ship. During the day, the group had an opportunity to observe two Terrier firings, conducted as part of the ship's evaluation program of the surface-to-air missile. Capt. A. R. Gralla (USN), Commander of the "Norton Sound," was host to the group.

Capt. Ivan Kincheloe was the featured speaker at a meeting held later in the month at Edwards AFB. Capt. Kincheloe, who had been in England and flew back expressly to attend the meeting, gave an interesting talk on the X-15.

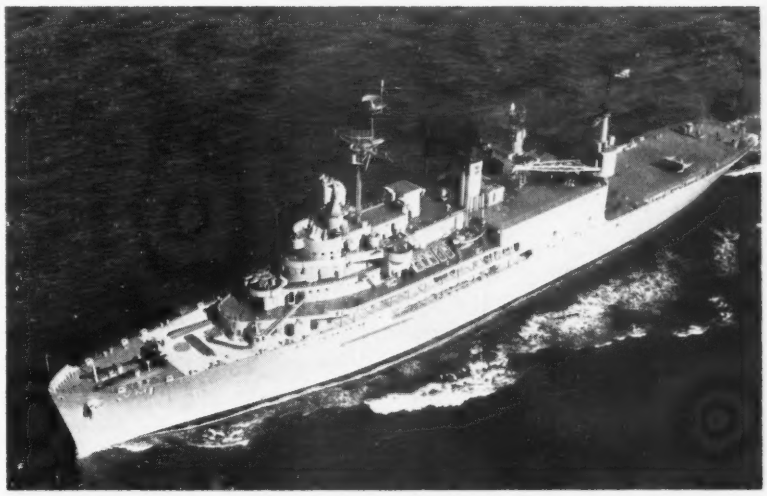
Columbus: The Fall program of the Columbus Section began with a September meeting highlighted by an address by Richard Schmidt of Edwards AFB on missile testing at the base, and a description of test facilities and problems encountered in making such tests. Prior to the meeting, Mr. Schmidt was interviewed on a local TV station.

The October meeting featured an address by Frederick Bagby of Battelle Memorial Institute on "High Temperature Material Problems Associated with Missiles."

With attendance at Section meetings now generally topping 100, arrangements have been made to meet this year in the auditorium of the new Physics Building on the Ohio State campus. The group has also launched a membership drive, with M. W. Jack Bell in charge.

Maryland: The September meet-

Missile Ship Host to Antelope Valley Group



"USS Norton Sound" (above), the Navy's first guided missile ship, played host to the Antelope Valley Section in September. Below, Section members inspect a target drone aboard ship.

ing of the Maryland Section was highlighted by the presentation of student awards in the group's annual essay contest for Baltimore schools. Section President Samuel Fradin presented the awards. This year's topic was "A Look into the Future."

Following the presentation of awards, John H. Fischer, Superintendent of Public Instruction, Baltimore City School Board, spoke on "Secondary Education for a Scientific Age."

Another highlight of the meeting was the showing of a new ARDC movie entitled "Animals in Rocket Flight."

New York: John R. Pierce, director of electronics research, Bell Telephone Laboratories, was the guest speaker at a joint meeting last month of the New York Section, the Basic Science and Communications Div. of the New York section of the American Institute of Electrical Engineers, and the Institute of Radio Engineers.

Discussing some of the current fancies and fallacies of space travel, Dr. Pierce drew on both technical studies and science fiction for source material. In the course of his entertaining talk, he touched on such subjects as what the earth and the planets will look like from space, potential uses of ion rockets, gravity and weightlessness, atmospheric controls for space vehicles, and the use of space ships for communications purposes.

Joseph S. Smith, Air-Tronics Corp., presided at the meeting.

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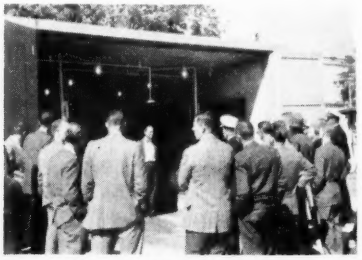
Niagara Frontier: Fall activities of the Niagara Frontier Section got under way in September with an address on rocketry by William M. Smith, manager, Rockets Div., Bell Aircraft Corp. Guest speaker at the October meeting was F. Gilbert of Becco Chemical Div., Food Machinery & Chemical Corp. Mr. Gilbert discussed the uses of hydrogen peroxide in rocketry.

North Texas: Richard C. Lea, assistant project engineer, The Martin Co., Denver; Lovell Lawrence, Chrysler Corp. Missile Operations, Detroit; and Kurt R. Stehling, Naval Research Laboratory, Washington, D. C., were among the guest speakers at Section

Rear Admiral L. D. Coates of BuAer leads Navy group into Forrestal gas dynamics facility.

Research Chief J. P. Layton describes project to Rear Adm. Schoech (center) and Capt. J. Baranowski, commander of NARTS.



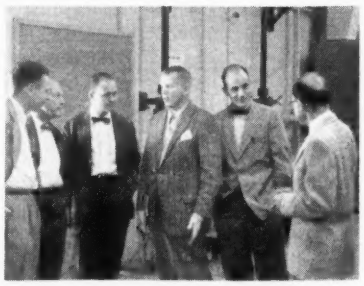
Jerry Grey explains combustion instability work in one of rocket test pits.

Princeton Shows Off to Navy

The Princeton Group welcomed a delegation of Navy officials to a two-day meeting Sept. 27–28 at the University campus. Also attending the affair were some 200 members and guests from New York and Philadelphia Sections of ARS.

Rear Admiral W. A. Schoech, Deputy Chief of the Bureau of Aeronautics, led the Navy delegation and gave a talk on weapons systems management on the first evening of the meeting. He urged university and industry scientists and engineers to keep in mind their responsibility to be selective in their development projects, to avoid wandering too far away from the "state of the art curve."

On Saturday morning, Sept. 28, tours of the James Forrestal Research Center were conducted for the entire group. In the afternoon, the Princeton-Rutgers football game was the order of the day.



Forrestal brain trust includes Irvin Glassman, Thomas Warfield, Grey, Layton, John Fenn and Martin Summerfield.

meetings earlier this year. About 75 people heard Mr. Lea discuss the Viking rocket, while Mr. Lawrence's talk on the future of rocketry and Mr. Stehling's discussion of Project Vanguard were heard by audiences of about 120.

Northern California: About 100 members and guests attended a recent joint meeting of the Northern California and Sacramento Stations which combined a tour of the Mare Island Navy Yard at Vallejo, Calif., and a dinner session highlighted by an address by Comdr. Edwin Kintner, nuclear superintendent at the yard.

Highlight of the tour was an inspection of the USS Bowfin, and the viewing and explanation of construction work on two new nuclear-powered subs.

In his address, Comdr. Kintner described the Navy reactor program and its probable effects on naval science.

San Diego: Karel J. Bossart, Technical Director, Convair-Astronautics, was the featured speaker at the first meeting of the San Diego Section held under the direction of the group's newly elected officers.

Mr. Bossart's talk on "Design Problems of Larger Rockets," and his remarks were based on a paper dealing with the same subject which he presented earlier this year at the High Altitude Rocket and Satellite Symposium in Cranfield, England. His discussion centered on a family of dimensionally proportional missiles with the same fineness ratio, and he considered the effects on weight at burnout of all the basic parameters, such as internal pressure, aerodynamic loads, thrust, handling and control. Slides were used to show that there is a decreasing return if size becomes too great.

Of special interest were some of Mr. Bossart's opinions, such as his questioning of whether exotic fuels are worth the extra cost except when they are used in small quantities for the later stages of multi-stage vehicles, and his skepticism as to the economic justification of interplanetary travel.

Southern California: A Confidential meeting marked the activities of the Section last month. Maj. George D. Colchagoff, Headquarters, ARDC, discussed the subject of "Research Vehicles Create Better Weapon Systems." In his paper, Maj. Colchagoff emphasized the need for an aggressive research vehicle program to improve weapon system quality, noting that rising costs and increased complexity of such systems, as well as a relative decrease in the basic reservoir of knowledge, makes such research programs vital. Current plans of ARDC to exploit this concept were discussed.

Dais lineup shows Richard Hurd, Lawrence Levy, James Harford, William Viets, Frank Caldwell, Stapp, King, ASME President William Ryan, Frank Shires, John Lee, Ben Dunn, Robert Mitton.

Stapp Holds Forth At Hartford Meeting

Col. John P. Stapp, ARS Director, was principal speaker at a luncheon sponsored by the Connecticut Valley Section in Hartford on Sept. 24.

The affair, held during the ASME Fall Meeting, attracted about 200 members and guests. Col. Stapp discussed the first two MANHIGH balloon flights and showed films of the gondola equipment and launchings.

He noted that the flying laboratory used in Maj. David G. Simons' record-breaking flight to 100,000 ft showed man can live above the earth's atmosphere for relatively long periods.

Chairman of the luncheon was Charles H. King Jr., of United Aircraft, president of the Section.

"There was an unearthly shove," Stapp tells press, in recounting sled experiments.

A second classified meeting will be held on Nov. 18. This meeting, at the Secret level, to be co-sponsored by the High Energy Propellants Group of ONR, will highlight a symposium on "Considerations of Solid and Liquid Propellant Ballistic Missiles."

At this meeting, two speakers will present formal papers and two others will deliver comments. James D. Burke, Jet Propulsion Laboratory, will present a formal paper on tactical missiles and Max Hunter of Douglas Aircraft Co. will deliver a paper on strategic missiles, while H. Larry Thackwell of Grand Central Rocket Co. will comment on solid propellant missiles and Milton Farber of Aerojet will comment on liquid propellant missiles.

STUDENT CHAPTERS

Georgia Tech: The Georgia Tech Student Chapter had an active summer. At a meeting early in July, members of the chapter decided to construct a laboratory demonstration rocket test stand similar to the one at Purdue University. Work will be carried out under the supervision of Prof. Mario Goglia of Georgia Tech.

Later meetings in July featured Bell Aircraft films of the X-2 and an Arma Corp. film entitled "Mission Bullseye," as well as a student lecture and discussion of the Vanguard rocket vehicle. The latter meeting attracted a record attendance.

In August, 50 Georgia Tech students and chapter members visited the Army rocket proving grounds at Redstone Arsenal as guests of Cliff Fitton and the Alabama Section. A Redstone missile firing and firings of solid fuel barrage rockets were included in the tour of technical facilities.

At a meeting late in August, John Kinney, research chemist from the Georgia Tech government research projects group, gave a lecture on the fundamentals of liquid fuel chemistry, with emphasis on new developments in boron hydrides.

Teal Takes to the Air

New Temco drone as it might look just prior to being destroyed.

Tagged the Temco Teal, the Navy's new rocket-powered drone XKDT-1 successfully passed its first flight test recently. More significant, says motor-manufacturer Phillips Petroleum, was the concomitant confirmation of an important scientific breakthrough in the field of solid propellant rocketry.

In developing the motor for this particular vehicle, Phillips reports that it solved a series of difficult problems. Among them:

- Obtaining flight duration in excess of eight minutes.
- Using solid fuels that provide—within the same motor—both the initial boost and subsequent sustained thrust without interruptions in power.
- Controlling generated heat to prevent damage to electronic and metal parts.
- Providing metal parts of light weight.

Moreover, says Phillips, the solid fuel (also made by Phillips) is produced from readily available petrochemicals.

The drone itself was designed and manufactured by Temco Aircraft Corp. It is 12 ft long, 10 in. in diam, has a wing span of 58.8 in., and flies at transonic speeds at 50,000-ft altitudes. An important feature of the drone, in addition to its sustained flight and high speed-high altitude capability, is its ability to signal near misses.

GE Gets Talos Order

The Navy has awarded General Electric Co. a $5 million contract to develop an improved shipboard handling and launching system for its Talos surface-to-air guided missile.

In Print

(CONTINUED FROM PAGE 12)

all three branches of the Armed Services" nor in a "production" status.

Despite some inaccuracies, Mr. Burgess has supplied us with a complete and useful description of a multitude of missiles and something of their history. If it is important to someone to know all this, the book can be commended to him. The last chapter correctly brings out the often-overlooked problem of producing, as distinct from designing, a reliable missile.

All in all, Mr. Burgess has condensed a large amount of research into a lucid, small and technically competent book. The serious practitioner of guided missile technology would be well-advised to get it and read it.

Rally Round the Flag, Boys! by Max Shulman, Doubleday & Co., New York, 278 pp. $3.50.

"A wonderfully funny novel about love and missiles," says the book jacket about Max Shulman's latest opus on the foibles of our times, and, while book-jacket descriptions are seldom accurate, in this case the nail is plunked squarely on the head.

Anyone who has ever had anything to do with missiles, or has been in the Army, or even lives in suburbia, will get a boot out of the book. Shulman has always been a funny man, but in this instance he has also written a good novel, with characters drawn from life.

The scene is Putnam's Landing, Conn., a commuting village with three social strata, vertically divided and constantly at odds with each other. First there are the old Yankees, then the Italians and last, but by no means least, the commuters, "also called the lambs, or the pigeons, or the patsies."

Results Are Devastating

Into this raging maelstrom is tossed an Army Nike base, with results that are truly devastating. In the course of his story, Shulman dissects subjects ranging all the way from guided missiles to misguided marriages, and introduces us to a fascinating array of characters.

Take the Army personnel, for example. There's Captain Walker Hoxie, "a guided missile expert—a category woefully short in the Army but even more woefully short in private industry. He could have resigned his commission and gone to work for a fancy salary at some missile or electronics factory, but the hateful thought never entered his mind. He flatly did not want to be a civilian. He had never had a good day with civilians in his life. . . ."

Or Colonel Thorwald, the battery commander. "The colonel was a portly, patient West Pointer of 60 years who had learned that the only way to run a Nike command was to keep smiling. You could never find a community that wanted Nike; you could never find enough qualified officers to run a battery. This left you two choices: Smile or Section 8."

Then there's Shulman's collection of Putnam's Landing characters, like Grady Metcalf, a new kind of juvenile delinquent. "The tenement that spawned him was a $40,000 ranch house on two well-kept acres, and the sight of a switchblade would have put him in shock. Grady was a member of the new school of juvenile delinquency, the You-Too-Can-Be-A-Rebel School. The headmasters were Elvis Presley and the spook of Jimmy Dean, and the entrance requirements were completely democratic."

The impact of the Nike base on Putnam's Landing makes for a fascinating story culminating in a Fourth of July fireworks display capped by an awesome accidental Nike firing that brings the book to a rousing close.

"Rally Round the Flag, Boys!" is a novel that can be heartily recommended to anyone looking for a warmly humorous story of American life today.

—I.H.

BOOK NOTES

George Sutton, ARS National Vice-President, recently received a copy of the pirated Russian translation of his **"Rocket Propulsion Elements,"** originally published in this country in 1949 by John Wiley & Sons. The Russian edition, published in Moscow in 1952, contains the original errors and includes an unclassified bibliography on rocket propulsion by the same author which appeared in the *ARS Journal* in 1952. The Russians have translated some 200 scientific books without license and without paying any royalties.

° ° °

Springer-Verlag recently published Fritz Zwicky's **"Morphological Astronomy"** (299 pages, DM 49.60). The new book analyzes the fundamental aspects of morphological research and applies morphological methods to numerous problems in astronomy, with special attention to the investigation of the large-scale distribution of matter in the universe and related cosmic phenomena.

Feedback

(CONTINUED FROM PAGE 8)

We have read the article on page 33 of the August number, but it does not say just what Volume 1 is.

Please send us the desired information. Thank You.

JULIA SAUNDERS
Enoch Pratt Free Library
400 Cathedral St.
Baltimore 1, Md.

A number of letters have been received asking this same question. Actually, the answer is simple. ASTRONAUTICS *is the name that was used for more than 12 years for the original* JOURNAL *of the* AMERICAN ROCKET SOCIETY, *with 60 numbers published under this title. When the same title was chosen for the new ARS publication, the first 60 numbers published under that title were considered as Volume 1, with the first issue of the new magazine becoming Volume 2, No. 1, for copyright reasons—Editor.*

Rocket Course Offered

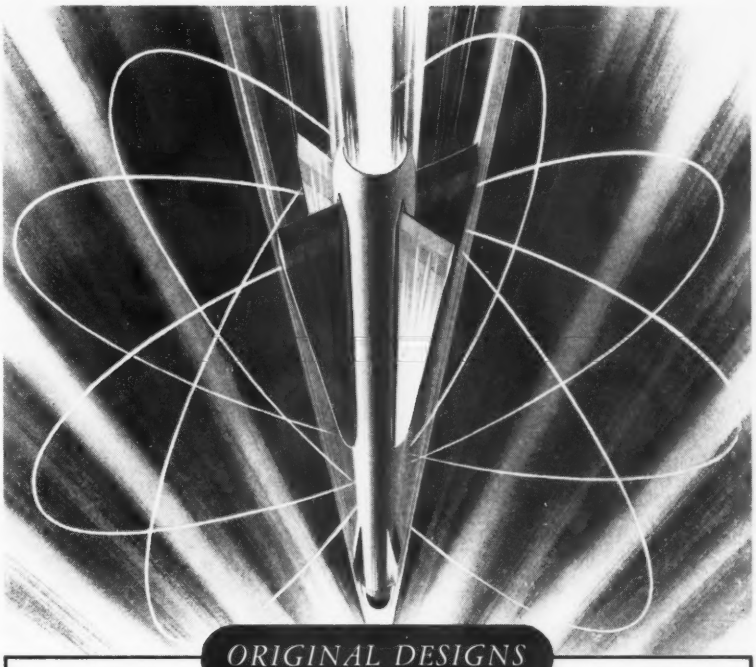
A comprehensive graduate course in rockets and rocketry is being offered at the Polytechnic Institute of Brooklyn this fall. Under the direction of Dr. T. Paul Torda, professor of mechanical engineering, the course includes background material as well as design principles and engine programming.

Missile Offered to U. S.

The Malkarra, a new guided weapon designed and developed by Australians, is reported to have great accuracy against targets, and can destroy a tank at long distances. The Australian Minister for Defense has suggested that the new missile and the pilotless aircraft target, the Jindivik, might also be useful to the United States.

Radar Check

Lockheed has started construction of a new facility for the design and testing of advanced missile antennas and radar devices. Located at Sunnyvale, Calif., the unit will include, in addition to a general laboratory, a temperature-controlled vibration-free building for making reflectivity measurements, an area for measuring antenna patterns, and an anechoic chamber for use in making precision measurements of radio frequency signals.



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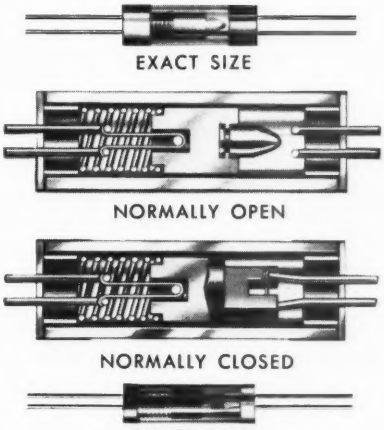

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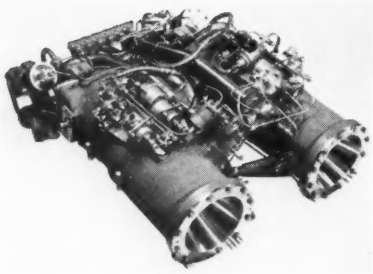

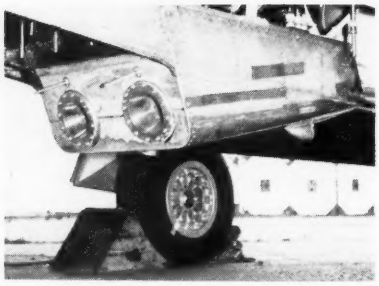

Bomber Booster **Napier "Double Scorpion" auxiliary aircraft rocket engine of undisclosed power recently aided English Electric Canberra twin-jet bomber to set a new world altitude record for airplanes of 70,000 ft.**

Synthetic Atmospheres

(CONTINUED FROM PAGE 48)

Low pressure will reduce the total weight of air and the required skin thickness of the hull; it will also minimize air losses through leaks. But the crew will require a minimum oxygen pressure of 90 mm Hg.

Oxygen partial pressure at sea level is 160 mm Hg. It is theoretically possible to breathe 100 per cent pure oxygen at 90 mm Hg, but it is questionable whether such an atmosphere is physiologically adequate for a longer period. By adding an inert component to the oxygen, a suitable atmosphere can be obtained.

Nitrogen Is Undesirable

Nitrogen is undesirable for this purpose because of its tendency to cause "bends." Helium, often considered, has acquired a reputation as a leak finder, capable of diffusing rapidly through even the tiniest holes. Gases such as argon have been suggested, but not enough is known about them.

In succeeding calculations, it is assumed that the atmosphere will be half helium and half oxygen at a total pressure of 200 mm Hg. Crew members will have to acclimatize themselves gradually to the composition by breathing the helium-air combination for several days. Moreover, all crew members will have to become familiar with the ill effects eventually produced by the low total pressure.

The problem of temperature control in a space ship will depend on the rotational movement of the vehicle, among other things, particularly in regard to solar radiation. A lunar vehicle, it is assumed, will be attitude-controlled and will turn the same side toward the sun at all times. This surface of the ship can be treated to obtain high reflectivity, while the dark side can be given a coating with high emissivity. Since emitted energy follows the fourth power radiation law, it is desirable to keep the dark side at maximum temperature—that is, as close to cabin temperature as is feasible.

Additional Heat Generators

There are, of course, a number of heat generators other than the sun that must be dealt with if comfortable atmospheres are to be created for future space crews. Among them: Electronic equipment (despite the advent of the transistor, this is and will continue to be a major heat source); the crew itself; and, less important, cooking facilities, lighting, and the like. For approximate Btu values of these various sources, see the table on page 48.

The best way to remove this heat from the atmosphere of the space cabin is through use of a heat exchanger. The heat would be absorbed by a chilled fluid, which would then be pumped through a radiator on the dark side of the vehicle. This system will also permit easy removal of water vapor which may condense in the heat exchanger.

Temperature and humidity can be controlled by by-passing a part of the cabin air and mixing it with undercooled, dry air from the heat exchanger-condenser. However, one other factor should be kept in mind. Each crew member will expire about 175 cu cm of water per day. And, to keep the perspiration rate low, the forced draft system must be designed for optimum exchange of air in the cabin with minimum draft. Otherwise, the perspiration rate could reach 500 cu cm per day.

In addition to being cooled and dried, the air will have to be purified. Exhaled carbon dioxide, for one thing, will probably amount to 1008 g per day. If this is allowed to build up to 2 or 3 per cent of total atmosphere, breathing will become laborious. When it reaches 5 per cent, the carbon dioxide becomes toxic.

In spite of this danger, it is desirable to maintain carbon dioxide at the highest possible level, because this facilitates the purification process. Maximum carbon dioxide level tolerable for prolonged exposure is still unknown, but 1 per cent seems to be a good estimate. For other toxic gases that may be present in the space cabin, see the table on page 48. Note that oxygen is a toxic gas when it constitutes more than 80 per cent of the atmosphere and in presence of pressures above 425 mm Hg.

Besides toxic gases, there will be combustible gases such as hydrogen and methane which must be removed. Hydrogen, for example, forms explosive mixtures with air over a very wide range. Moreover, gases with intolerable odors, such as indole and skatole in feces, and ethereal sulphates in urine, must also be removed. Carbon dioxide removal will undoubtedly be the prime consideration in the design of the purification apparatus. One economical way of accomplishing this would be through absorption of carbon dioxide by various chemical compounds. On a weight basis, lithium oxide appears to offer the most promise.

It has been estimated that 700 g of lithium oxide will be required per man per day to absorb the 1 kg of carbon dioxide expired. The lithium oxide would be used in the form of a moist pellet filter.

Sun Would Provide Heat

For prolonged journeys of course, the lithium oxide will have to be generated. This can be done quite easily by heating the resultant lithium carbonate to reform lithium oxide and water. The sun would serve as an excellent source of heat and the natural vacuum in space would insure complete withdrawal of carbon dioxide as soon as it is formed, thereby speeding up the process.

Most of the other gases could be removed by means of activated carbon, and the carbon, like the CO_2 filter, could also be reactivated. This would leave only a few gases which might cause trouble. Of these, hydrogen and methane, which are combustible, would be the most threatening. They could be removed only by completely venting the cabin when the percentage reaches the dangerous

level, or by conducting the air over glowing platinum, which would oxidize hydrogen and methane to water and carbon dioxide.

Some oxygen will be used for respiration, and some will be lost through other oxidation processes and through leaks in the hull. This lost oxygen must be replaced. The most convenient way would be to carry extra oxygen stored in liquid form. This will require elaborate insulation to keep evaporation at a minimum, and specially designed rotary equipment, which would substitute centrifugal force for the absent gravitational force, to assure separation of gaseous and liquid oxygen at the outlet.

Can Be Stored Only as Gas

The amount of helium necessary to balance out atmospheric composition can be stored only as a compressed gas, despite the weight penalty imposed by the necessary pressure vessels. Because helium density increases at reduced temperatures, it may prove profitable to store helium bottles inside the liquid oxygen.

A good deal has been written about the possibility of balancing the expired carbon dioxide of the crew with an algae system. Some authors have even gone so far as to propose the utilization of human waste for the establishment of a closed ecological system. But an algae culture is a very intricate system that has a number of drawbacks, and it is doubtful that it can be adapted to a space vehicle.

Among other things, the algae system is only 25 per cent efficient. Then, too, providing proper growth conditions for the algae would prove difficult in a space ship. For example, in addition to carbon dioxide, the algae require a lot of water as well as certain elements such as nitrogen, magnesium, iron, phosphorus and the like which cannot be obtained from human waste in the specific concentrations required for growth of the algae.

Moreover, algae are extremely temperature-sensitive; density of the algae must be kept at a specific level; and it has been estimated that it would take 1230 gal of water a day just to grow enough algae for one man. Last, but most important, it was recently discovered that at least some algae produce deadly carbon monoxide, as well as oxygen.

Thus, the use of algae in atmospheric regeneration seems unsuited for space vehicles. On the other hand, this system could eventually find applications on planets lacking vegetation or moons where such drawbacks would prove inconsequential.

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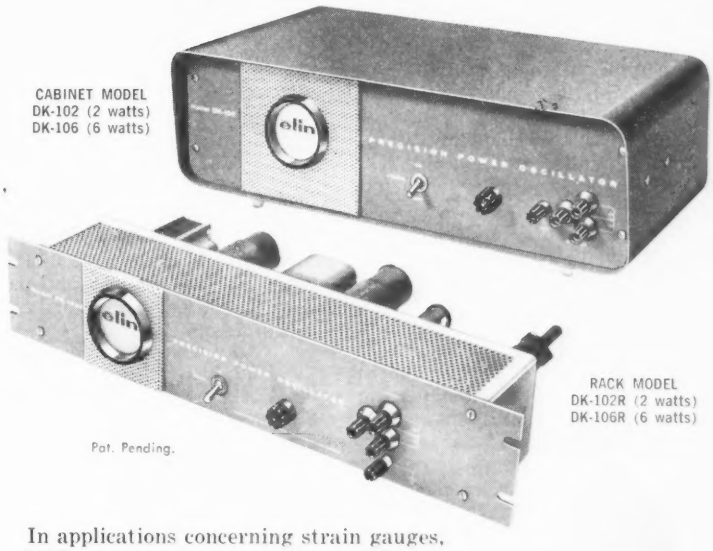

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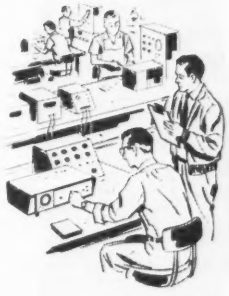

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from the patent office

BY GEORGE F. McLAUGHLIN

Turbojets Power Supersonic Wind Tunnel

A newly designed continuous-operation, supersonic wind tunnel of the nonreturn type is powered by two turbojet engines, one serving as a large air source, and the other providing a large capacity air sink.

The principal object achieved is a testing facility in which none, a part, or all of the tunnel inlet air may be lowered in relative humidity as required, with little pressure loss, to prevent condensation in the tunnel test section.

Water injection is utilized in the turbojets to replace the air bled off, and a diffuser replaces the exhaust nozzle of each engine.

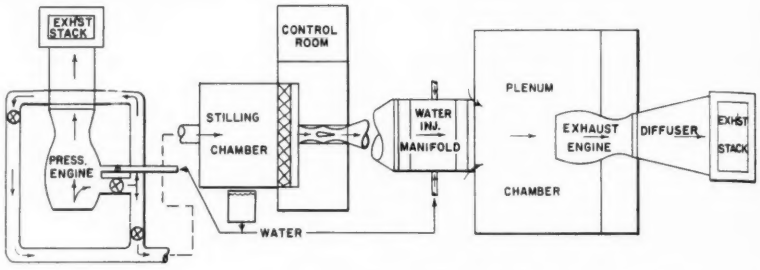
An exhaust turbojet engine of any conventional make is housed aft of the test section and may be run at full operating speeds without being starved for air, resulting in a lower pressure downstream of the test section.

Design requirements of the bleed system and heat exchanger are determined primarily by the desired temperature and pressure at the tunnel inlet. The tunnel inlet pressure required depends upon the ratio of the tunnel inlet or stilling chamber pressure and the tunnel outlet or plenum chamber pressure drawn by the downstream engine such as an Allison J-33. Using two engines, one for supplying air and one for drawing air, a test section velocity of Mach 2 is provided by a pressure ratio of between 1.7 and 2.0. The maximum vacuum of the plenum chamber pressure which can be pulled, and which is limited by the maximum turbine-exit temperature, is of the order of 11 in. of mercury.

To obviate the need for air drying equipment, an inlet temperature high enough to avoid condensation in the tunnel test section is specified. With the compressor outlet temperature at about 400 F and the temperature loss through the tunnel walls being small, it has been found that at a tunnel-inlet temperature of 450 F there will be no condensation except for extremely humid conditions. This inlet temperature is satisfactory for aluminum alloy, brass, and silver soldered models.

Besides testing of aircraft models and components, the supersonic wind tunnel is useful for other testing, such as mockups for airplane skin cooling systems, wind-driven turbines, or ground static tests of engine air duct inlets, where a large source of positive or negative air pressure is required.

The inventor claims the tunnel is economical to run, simple in arrangement, easy to construct, and particularly, that it is operable for long periods of time.

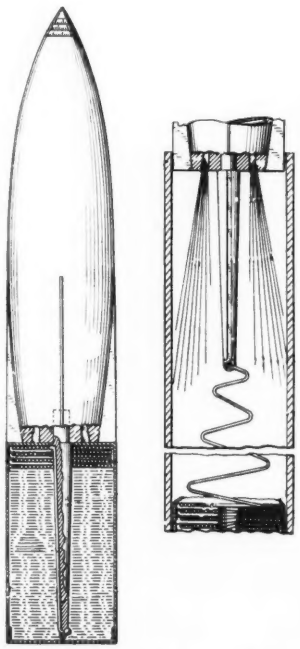


Schematic plan of continuous-operation supersonic wind tunnel system.

Supersonic wind tunnel (Patent No. 2,805,571) Harry M. Graham, Dallas, Tex., assignor to Chance Vought Aircraft, Inc.

A-A Missile Creates Cable Barrier

An inexpensive antiaircraft missile has been devised to minimize the effectiveness of evasive action by enemy aircraft. Main feature of the invention is a relatively lightweight wire or cable carried by the rocket. When extended, this wire creates an antiaircraft obstacle difficult to see and to avoid, and capable of destroying the aircraft.



Sectional views show anti-aircraft missile containing coil of wire. The right view shows rocket after firing, and before leaving launcher.

One end of the wire is anchored to a tapered shaft secured to the rocket. The cable is coiled to form a compact unit which will unwind with minimum resistance and without binding.

When the rocket is fired, exhaust gases push against the top of the cable assembly, forcing the rocket out of its launching tube and withdrawing the shaft from the cable assembly. As the rocket gains altitude, the cable is unwound layer by layer. Piano wire, woven "picture wire," or other small gage cable may be used. The high speed of the rocket keeps the cable substantially taut. Cable length is governed by the caliber of the rocket and the gage of the cable.

The rocket is of conventional construction, provided in the rear with peripherally disposed exhaust ports and four fins. The coiled wire assembly is secured to the rear and sealed by a housing to protect the wire during storage or shipment.

The housing is of a combustible material, such as heavy gage celluloid. When the rocket is fired, by means of the conventional electrical trigger circuit, the exhaust gases ignite the housing which burns away in the launching tube, so that another rocket may be inserted readily.

For convenience in manufacture, storage and handling, the coil and shaft may be secured to the rocket after delivery to the launching site.

Rocket missiles (Patent No. 2805,-622) Bruno Cammin-Christy, New York, N. Y., assignor of portions to John Radtke, Columbia Heights, John Joseph Radtke, Queens Village, and August Radtke, Valley Stream, N. Y.

Anthropology

(CONTINUED FROM PAGE 28)

children learning about it, Congressmen allotting money for it, political leaders of the East and West praising their nation's contributions to its progress, and last, but not least, scientists and engineers blazing the trail toward its eventual accomplishment.

Nevertheless, we must face the question: "Why space flight?" As an implication of a waste of time and money on a hopeless venture, this question is rarely asked today. Few people still doubt that we can, for instance, establish satellites which will serve useful purposes. As a request for philosophical justification of the vastly greater long-range implications of astronautics, an answer must be given, and given as firmly, conclusively and decisively as possible. It has already been recognized that a good deal of thinking is needed to provide this kind of answer, and we are just beginning to deal with the problem. We should not, however, let ourselves be stampeded into frantic attempts to "prove" a need for rushing to Venus or Mars, because, to put it bluntly, there really is none *today*.

Acceptance of Space Vehicle

The important point is to understand why we should gradually accept the space vehicle just as our ancestors finally got around to accepting the wheel and the boat. There was a time—the Odyssey proves it—when it was almost inconceivable for the ordinary man to leave his peninsula or island and sail beyond the horizon into the unknown. We still haven't changed much in principle, because it is still inconceivable for many of us to consider our Earth as an island from which one day many men may leave for distant places, unknown to us, except in a general way, or which one day may be visited by people from far away, as an American citizen today visits the country of his extraction.

As a contribution toward answering this famous question, I propose to establish a broad perspective by formulating three fundamental laws of astronautics, shown on page 28, and examining their implications. These laws are the basic tenets in the pioneering of space flight, in the development of modern missile technology (as well as other technologies, notably the atomic), and in our ambitious plans and hopes regarding the future of astronautics.

The first law is astronautics' challenge to man to write his declaration

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Engineers and scientists are invited to address inquiries to: Research and Development Staff, Palo Alto 35, Calif.

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of independence from a priori thinking, from uncritically accepted conditions, in other words, from a past and principally different pretechnological world clinging to him. This can be done. The Declaration of Independence and the Constitution of this country prove it. Implementation may take a long time, but the first breakthrough to its formulation is of decisive importance. These documents would probably never have been written in Europe, although the French Revolution is credited with stimulating much of the thought that went into them. A new world, mental distance emphasized by physical distance, and a fresh sociological start were necessary for their formulation.

Contains Many Variables

Europe and America (not only the United States), though related, are two separate differentiations of the integral of human civilizational capacity, like the Chinese, the Indian, the Roman, Hellenistic, Hebrew and many other civilizations before them. This integral contains innumerable variables, and the number of possible differentiations in time and space is therefore equally large, provided man's spirit is not snuffed out in the confinements of a too narrow cosmic environment.

Here we find an important trend: The gigantic scope of astronautics is doubtless one of the more immediate reasons for its fascinating challenge. It offers to take man where he has never been before, and therefore compellingly appeals to his inborn curiosity, love for adventure and dedication to research. However, beyond this, the most fundamental reason may be deeply hidden in a past so distant that it exceeds by far even the lifespan of his own species. A characteristic of life on this planet, including man, is the desire to expand, to spread, to instinctively respond in an aggressive manner to the unknown, and to regard the seemingly unattainable as a provocation which must not remain unanswered.

The first great response of this type came with the expansion of life from the oceans to the land. Amphibia and reptiles reproduced the original conditions existing in the primeval oceans in their eggs, which were then hatched by the sun in a friendly, warm climate, the only climate in which they could exist. With a few exceptions, they remained crawling animals. Their bodies were in close contact with the ground, resulting in extensive heat exchange. Hence, their blood temperature followed, and today still follows, that of ground temperature. It cannot be kept at a constant moderate level like that of the mammals.

The development of the mammal, the most versatile and perfect land animal, was a brilliant biotechnical achievement. Divorcing the body from the ground by means of legs freed the body from slavishly following the temperature cycle of the soil, permitted the development of insulating furs, and allowed the maintenance of a fairly constant temperature around 98 F, about the same as that of the primeval ocean waters. Now it was no longer necessary to lay eggs and depend on the sun for hatching. The brood could be developed in the motherbody itself. Therewith, life became almost independent of climatic conditions. The conquest of the land could be completed. Also, the lower atmosphere could be occupied in time by follow-on developments of the reptiles, which showed a better growth potential for this environment than mammals.

Found Itself Stymied

Then life found itself stymied on the borders of space. There are no biological means where direct application would permit living beings to enter and cross space. It is intriguing to think that life may have answered this challenge by producing a new amphibian—man—whose restless mind reaches beyond the confinements of his biological world. The human brain alone is capable of utilizing certain superior qualities of inorganic matter for entering space.

And now begins the next act in the gigantic drama, with man holding a key role. Surrounded by protective shells, life sets out to spread to other worlds. Possibly it does so from several nuclei in space, many light years apart. In this perspective, it appears more difficult than not to assume that our response to the challenge of space flight should be limited to building earth satellites, unless we choose to impose this limit on ourselves. It is part of our heritage as children of this planet to seek out other worlds, to grow and to mature with our expanded capabilities into degrees of freedom and independence which would make present-day societies appear like the incredible confinements of medieval communities or African tribal regulations. It is a historical fact that man's mind and spirit grow with the space in which he is allowed to operate.

The importance of the second law can be measured by the effect which the expansion of European man all over the earth had on the development of civilization. Medieval European civilization, frozen in the narrowness of its small, rigidly controlled communities and tightly bound to an all-powerful religious dogma, was in the

Inspection Room for Missiles

Welded joints in missile air frames are radiographically inspected in this specially designed building. Lead-lined doors and panels shield the darkroom, control room and adjacent production areas from radiation. The facility was designed and built for Reynolds Metals Co., Sheffield, Ala., by Ray Proof Corp.

12th and 13th Centuries dangerously close to becoming another static civilization, like those of ancient China, Japan, India or the Incas on this continent. Before it stretched a dreary succession of generations unchangingly channeled through a rigid, if not tyrannical, social and philosophical system for whose maintenance alone they were permitted to exist. The sudden recognition that here was the wide and beautiful Earth waiting to be taken by man, overwhelmed and emboldened the great thinkers of that time, notably Giordano Bruno, Nicolaus Copernicus, Galileo Galilei and Johannes Kepler. This was the crowning achievement of the Renaissance, and forever shattered the world of dogmatic scholasticism.

Now we begin to realize that the solar system, and probably even part of this galaxy, can be ours. The consequences, for all phases of human existence, of the practical application of the second law of astronautics during the coming centuries almost defies our imagination, just as the world of today would be almost inconceivable to the Renaissance pioneers. We today are merely the shipbuilders for the men and women who will enter new era of discoveries and lay the foundations for those who will come after them, those who will develop planetary technologies and create cosmic civilizations.

The Third Law

The third law specifies this anthropological character of space operations as we humans can conceive it. It does not imply as desirable the brutal conquest of other worlds, such as happened frequently in the colonization of this world of ours. It does, however, proclaim man's natural right to explore and attempt to fertilize with human skill and wisdom all those parts of the universe which he can reach, whether or not they are inhabited by intelligent beings. This right is equally at the disposal of other civilizations in the universe if they can reach us first, or, if, in the course of their expansion, they reach other worlds before us.

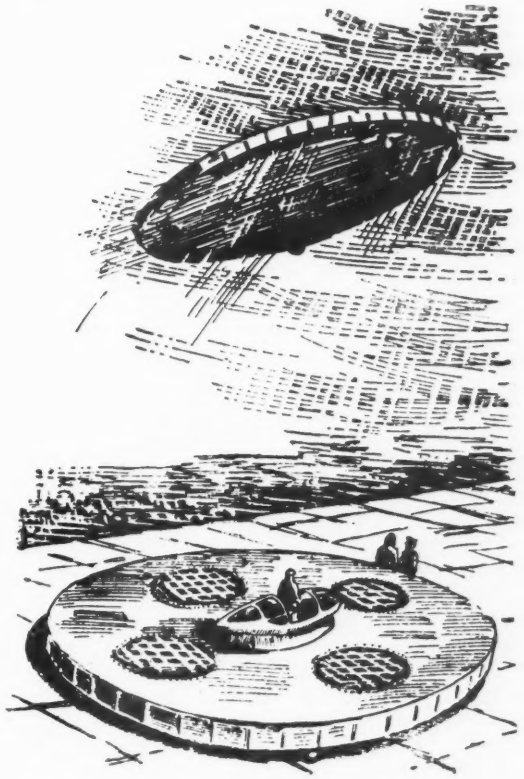
The results of man's contact with another civilization in space, if and when this ever happens, can only be speculated upon. Of basic importance right now is the fact that man is the only source of intelligent life known to us, which gives him the right to expand, to develop and to enrich the foundations of his existence to the limits of his capability. In the light of this perspective, expeditions to other planets, i.e., the age of discovery, is again just a beginning, no matter how advanced it may appear to us.

If all the evidence is in, future generations may find solutions to the problem of living elsewhere in the solar system, or even in interstellar space, thereby giving space flight its ultimate anthropological meaning. It is not very important that we cannot yet specify in more than a general way the utility of living elsewhere in space, because we are about as competent to judge this as Democritus was to judge the utility of atomic knowledge which he so diligently pursued.

This does not mean that consideration of utility should be overlooked. On the contrary. However, astronautics, like all endeavors of large scope, has both an immediate, utilitarian aspect, and a long-range, fundamental aspect. It is not only sensible, but imperative, to establish the utility of a particular project such as an artificial satellite, a lunar probe or an artificial comet. We can also define the utility of a manned exploratory flight to Venus or Mars. Yet all these utilities are limited to special scientific or technical considerations, or to arguments based on military or political expediency. They constitute a professional challenge to a limited group of people, as does a supersonic airplane, the Mt. Palomar telescope, an unconquered mountain peak or a sandstorm observed on Mars.

If this were all, one could well take

Red "Saucer"



Russian newspapers last month reported the successful flight testing of a jet-propelled "flying platform" at Tushino Airport near Moscow. In general appearance, the saucer-like ship resembles the U. S. Navy's flying platform, except that it has an enclosed cockpit and four vertical supports similar to table legs, with metal gridwork extensions.

The sketches above, showing the platform in the air and on the ground, originally appeared in a monthly Soviet science magazine.

space flight or leave it alone. The anthropological challenge of space flight, however, goes much deeper. Its perspective and meaning, which alone lend magnetic appeal, can be derived only from the long-range aspects, which align it alongside the highlights of life on this planet.

Realism of Vision Needed

We must be realistic, but there is a wrong kind of realism, timid and static, which tells man to live for his existence alone and not to rock the boat. The kind of realism we need is the realism of vision—the realism of a Columbus, of our Constitution, of a Benjamin Franklin, of an Albert Einstein, of a Konstantin Ziolkowsky and of a Hermann Oberth.

This is the realism which lives by our first law, the very foundation of man's development—the law that states that we are free to grow in this grand universe of ours unless we put the yoke around our own necks. In this spirit, it will not be too difficult to deal with the immediate utilities which rightfully provide the formal justification for each subsequent phase of astronautical development.

However we look at astronautics, it is impossible not to feel its challenge to human destiny. For this reason, space travel needs, and will find, the support of all civilized nations as we gradually and painfully move into the cosmic age of man.

PET Rocket

Possibly the smallest solid propellant rocket motor ever offered commercially, the PET (propulsion, experimental test) is 1.5 in. in diam, 4.75 in. long, and weighs 0.6 lb. Developed by Atlantic Research Corp., the motor uses AR's Arcite solid propellant and develops approximately a 40-lb thrust for one second. Except for minor modifications, PET is like the spin and retro rockets developed by the firm for Project Vanguard.

Talos Takes Off

Navy's newest surface-to-air guided missile Talos is put through its paces at White Sands Proving Ground prior to joining the fleet some time next year. The missile will make up the major armament of the light cruiser USS Galveston, now undergoing conversion at the Philadelphia Naval Yard.

Astronautical Engineers

(CONTINUED FROM PAGE 38)

engineering fields.

In fact, one might be tempted to say that the present practice of issuing various undergraduate engineering degrees smacks of overspecialization at an early stage. Consider the new engineering graduate appearing on his first job. In an overwhelming majority of cases, he has neither the specialized knowledge of his newly chosen field to permit him a qualitative evaluation of the product or activity involved, nor sufficient grounding in the fundamentals to permit him to engage in basic work on a truly professional level.

Thus the beginning of most young engineers' careers is a string of routine or semi-routine, and at best quasi-engineering, work assignments which are damaging to their morale and wasteful of their talents.

Mr. Gustavson's solution to this undesirable situation would be to offer the student an opportunity to specialize early enough so that he could enter his field able to speak its language and aware of its problem areas. The question which should be raised here is this: Would such a graduate be able to enter his field as a full-fledged member capable of making significant contributions?

The answer to this question appears to be a negative one. It is difficult to imagine a young man with a brand new diploma in astronautical engineering who could with equal facility enter such diverse fields as propulsion, guidance, structures or aerodynamics, and proceed to make contributions in these fields which would be significantly superior to those made by a young M.E., E.E., C.E. or Ae.E., respectively. The young astronautical engineer would still be forced to spend some sort of "apprenticeship" period in industry, which is not a significant improvement over the existing situation.

Even without the high degree of specialization called for by the article, the current undergraduate engineering curriculum often glosses over fundamentals. This is best evidenced by the fact that almost all graduate schools demand as required subjects further study of mathematical analysis, thermodynamics, stress analysis and other topics covered in undergraduate school. Any increase in specialization would only serve to further cut the time available for these subjects.

Would it not be better to devote some of the time consumed by a more or less superficial study of the various specialties to a more thorough grounding in engineering fundamentals? The product of such a curriculum would be a well-rounded technologist who could apply his skill to *any* field and have a better understanding of *all* fields, and who could then carry on his specialization in his chosen field through formal education in graduate school or on the job in industry.

Time Element Is Important

Another serious objection to the creation of new engineering degrees in the various "brand-new" fields is the time element. This is briefly mentioned in Mr. Gustavson's article when he quotes George P. Sutton, who points out that "practical 'know-how' changes with the times and rapidly becomes obsolete as new discoveries are made." This, of course, is true of all other fields. For example, how many mechanical engineers leave college with a thorough understanding of current practices in, say, boiler design and construction?

Unfortunately, in our field this problem is much more serious. First, the advances made in missiles and astronautics follow one another at such a pace that it is difficult for people actively engaged in the field to keep abreast of them. Second, a very large portion of the work in this field is done in connection with military activities and remains classified for years. Thus, the astronautical engineering student

would be exposed largely to obsolete material.

The last, but by no means least, objection to overspecialization is its effect on engineering as a profession. The various engineering societies are doing a great deal of work in connection with establishing and consolidating the professional status of engineers, and raising engineering to the same level as that of other professions. This is a very serious problem, since it affects our status in society.

We might do well to take a brief look at the educational practices of other professions, such as law or medicine. I do not necessarily advocate that one should acquire a college education before entering a professional school (although much could be said of it). However, the other remarkable feature of educational procedures in these professions is that they require their members to receive a thorough grounding in *all the fundamental aspects* of their profession. Once that is established, usually by means of examinations, the young attorney or physician can proceed to specialize along whatever lines he sees fit, and educational institutions make suitable provisions for such specialization.

The most important result of this method of specialization is that the decision to specialize is made by a more mature individual who is familiar with the various fields of his profession. Compare this method of specializing with that of a young engineer, who springs, so to speak, fully grown from the brow of his Alma Mater, clutching a diploma which proclaims to the world that he is a "specialist" in some field of engineering.

Will Not Produce Good Men

To sum up, I do not feel that we should "get 'em young, train 'em early." Such a procedure may be satisfactory in producing a pool of industrial skills, but will not do when the production of capable, creative professionals is the aim. Instead, we would be doing a service to both our field and our profession by encouraging specialization *after* the fundamentals have been mastered, when it becomes more meaningful and fruitful. This should be done even if it means extending the undergraduate engineering curriculum beyond the presently accepted four years.

The only results which will be achieved by encouraging specialization at a tender age would be the production of hordes of highly trained technicians who could claim neither the title of professionals nor the label of educated men.

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Combustion Conference Planned

Diffusion flames and flame stabilization will be the topics discussed at the second technical meeting of the provisional western states section of The Combustion Institute on Dec. 9 at Cal Tech. At least half a dozen papers will be delivered.

Britain Offers Missile

Bristol Aeroplane Co. (U.S.A.) Inc., announced that Britain is offering its supersonic Bristol/Ferranti Bloodhound guided missiles to certain British Commonwealth and West European countries.

The Ministry of Supply will release to these countries information about the Bristol-developed weapon system within prescribed security limits. Bloodhound, one of the first practical guided weapon systems in the United Kingdom, is expected to replace fighter aircraft.

Bristol Aero-Engines, Ltd., produces the ramjet power units, and Ferranti Ltd. produces the radar and servo-control equipment.

government contract awards

Lear Developing Advanced Aircraft Instrument Panel

Lear, Inc., has received a $250,000 Air Force contract for the development of an advanced aircraft instrument panel as part of the broad cockpit improvement program at Wright Air Development Center. The program represents an effort to solve the problems of control of new high performance aircraft.

Solar Gets $4.5 Million Contract for Power Units

Solar Aircraft Co. has received a $4,500,000 supplemental order from the Air Force's Air Materiel Command for gas turbine-powered airborne generator sets and spares for Boeing KC-97 Stratotankers. Used as an auxiliary power unit, it functions as an independent source for SAC tankers when they are not flying and furnishes auxiliary electrical power in flight.

Missile Job to Packard-Bell

A contract for research and development of missile test equipment has been awarded Packard-Bell Electronics Corp. by the U. S. Naval Ordnance Laboratory, Corona, Calif.

Navy Radar Contract

Canoga Corp., Van Nuys, Calif., has received a $1,087,458 contract from the U. S. Navy Bureau of Aeronautics for four of its C-band ground based radar systems, designed to track high speed, high performance missiles in flight. The Navy plans to use the system for missile testing at its Point Magu, Calif., site.

$2.5 Million Titan Contract

Rheem Mfg. Co.'s Rivera Electronics Div. has been awarded a $2,500,000 Air Force contract for equipment for the Titan intercontinental ballistic missile.

Nike-Hercules Components

The U. S. Army Ordnance Corps has ordered $2,050,000 in missile components from the W. L. Maxson Corp. for the arming and detonating system in the Nike-Hercules missile.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AEC

U. S. Atomic Energy Commission, Idaho Operations Office, Idaho Falls, Idaho.

Construction of flight engine test facility at the National Reactor Testing Station, $6,044,695. The FET installation, to be constructed in the Aircraft Nuclear Propulsion area of the NRTS, will provide a facility where nuclear engines can be tested in conjunction with air frames, typical crew compartments, and aircraft control systems, **Howard S. Wright Construction Co.,** Seattle; **S. Birch & Sons Construction Co.,** Great Falls; **D. L. Cheney,** Seattle, joint venture.

AIR FORCE

AF Missile Test Center, ARDC, USAF, Patrick AFB, Fla.

Tool-flaring, wrench-pipe, wrench set, $28,727, **J. G. Christopher Co.,** 416 East Bay, Jacksonville, Fla.

Paper, recording, $26,889, **Sanborn Co.,** 175 Wyman St., Waltham, Mass.

Major components for 205J plotting board and major components for 484A and 484B computers, $76,552, **Electronic Associates, Inc.,** Long Branch Ave., Long Branch, N. J.

ARMY

Corps of Engineers, U. S. Army, Office of the District Engineer, Jacksonville Dist., 575 Riverside Ave., Jacksonville, Fla.

Construction of G/M Instrument (GAT) Building, BOMARC-SAGE, AFMTC, Patrick AFB, Fla., $199,196, **J. C. Harper Construction Co., Inc.,** 960 Orange Ave., Winter Park, Fla.

Military Petroleum Supply Agency, Washington 25, D. C.

Jet fuel 5, $1,629,180, **Republic Oil Refining Co.,** Benedum-Trees Bldg., Pittsburgh, Pa.

Jet fuel 5, $439,504, **General Petroleum Corp.,** 612 S. Flower St., Los Angeles 54, Calif.

Jet fuel 4, $256,250, **Allied Materials Corp.,** 300 Braniff Bldg., Okla. City, Okla.

Jet fuel 4, $36,514, **American Petrofina Co. of Texas,** Div. of America Petrofina, Inc., Box 2159, Dallas, Tex.

Jet fuel 3, 4, $2,121,282, **Ashland Oil and Refining Co.,** 1401 Winchester Ave., Ashland, Ky.

Jet fuel 4, $89,594, **The Bay Petroleum Co.,** PO Box 957, Denver, Colo.

Jet fuel 4, $2,274,000, **The Carter Oil Co.,** PO Box 2514, Billings, Mont.

Jet fuel 4, $462,000, **Century Refining Co.,** PO Box 459, Garden City, Kans.

Jet fuel 4, $678,300, **Champlin Oil & Refining Co.,** PO Box 9365, Fort Worth, Tex.

Jet fuel 4, $2,411,500, **Cities Service Oil Co.,** 60 Wall St., New York, N. Y.

Jet fuel, $753,840, **Cities Service Oil Co.,** (Del.), 20 N. Wacker Dr., Chicago, Ill.

Jet fuel 4, $521,840, **O. F. Collinge Co.,** 14011 S. Central Ave., Los Angeles, Calif.

Jet fuel 4, $954,000, **The Consumers Cooperative Assn.,** Bulk-Petroleum Sales Dept., PO Box 7305, Kansas City, Kans.

Jet fuel 4, $4,390,595, **Continental Oil Co.,** PO Box 2197, Houston 1, Tex.

Jet fuel 4, $4,617,549, **D-X Sunray Oil Co.,** PO Box 381, Tulsa 2, Okla.

Jet fuel 4, $2,046,976, **Derby Refining Co.,** 420 W. Douglas, Wichita, Kans.

Jet fuel 4, $84,150, **Eastern States Petroleum Co., Inc.,** PO Box 5008, HSBG Station, Houston, Tex.

Jet fuel 4, $1,524,000, **The El Dorado Refining Co.,** Box 551, El Dorado, Kans.

Jet fuel 4, $1,796,760, **General Petroleum Corp.,** 612 S. Flower St., Los Angeles 54, Calif.

Jet fuel 4, $1,100,850, **Hunt Oil Co.,** 700 Mercantile Bank Bldg., Dallas 1, Tex.

Jet fuel 4, $176,100, **Jet Fuel Refinery,** 120 North 30 St., Box 1724, Billings, Mont.

Jet fuel 4, $1,732,550, **Kerr-McGee Oil Industries, Inc.,** Kerr-McGee Bldg., Oklahoma City, Okla.

Jet fuel 4, $889,133, **Phillips Petroleum Co.,** Bartlesville, Okla.

Jet fuel 4, $137,385, **Shell Oil Co.,** 50 West 50 St., New York 20, N. Y.

Jet fuel 4, $1,375,318, **Sioux Oil Co.,** Box 811, Newcastle, Wyo.

Jet fuel 4, $1,181,355, **Socony Mobil Oil Inc.,** 150 East 42 St., New York 17, N. Y.

Jet fuel 4, $2,600,855, **Standard Oil Co.,** (Indiana), 910 S. Michigan Ave., Chicago 80, Ill.

Jet fuel 4, $5,261,810, **The Standard Oil Co.,** (Ohio), Midland Bldg., Cleveland 15, Ohio.

Jet fuel 4, $2,118,500, **Standard Oil Co. of Texas,** PO Box 862, El Paso, Tex.

Jet fuel 4, $383,250, **The Texas Co.,** 135 East 42 St., New York 17, N. Y.

Jet fuel 4, $884,660, **Tidewater Oil Co.,** (East), 17 Battery Place, New York 4, N. Y.

Jet fuel 4, $2,709,000, **Tidewater Oil Co.,** 79 New Montgomery St., San Francisco, Calif.

Jet fuel 4, $3,510,818, **Triangle Refineries, Inc.,** PO Box 6867, Wm. Rice Station, Houston, Tex.

Jet fuel 4, $1,986,920, **Union Oil Co.** of

Calif., 617 West 7 St., Los Angeles, Calif.

Jet fuel 4, $882,011, **Utah Oil Refining Co.**, 10 W. Broadway, Salt Lake City, Utah.

Jet fuel 4, $1,093,000, **Utility Petroleum Co.**, PO Box 7096, Long Beach, Calif.

Jet fuel 4, $369,900, **Western Oil & Fuel Co.**, 227 Colfax Ave., North, Minneapolis 5, Minn.

Jet fuel 4, $345,900, **Seaside Oil Co.**, 330 State St., Santa Barbara, Calif.

Jet fuel 4, $2,885,202, **Cardinal Transports, Inc.**, 614 National Bank of Commerce Bldg., San Antonio, Tex.

Jet fuel 4, $119,300, **Leonard Refineries, Inc.**, PO Box 231, Alma, Mich.

Jet fuel 4, $3,497,800, **Howell Refining Co.**, Box 7188 Hackberry Station, San Antonio, Tex.

Jet fuel 3 or 4, $20,764,800, **Esso Export Corp.**, 45 Rockefeller Plaza, New York, N. Y.

Jet fuel 4, $3,141,684, **Gulf Oil Corp.** (Acting for Mene Grande Oil Co.), Gulf Bldg., Pittsburgh, Pa.

Jet fuel 4, $4,425,956, **Shell Caribbean Corp.**, 50 West 50 St., New York, N. Y.

Jet fuel 4, $3,766,284, **Esso Standard Oil Co.**, 15 West 51 St., New York, N. Y.

Jet fuel 4, $3,562,182, **Magnolia Petroleum Co.**, PO Box 900, Dallas, Tex.

Jet fuel 4, $3,205,926, **The Pure Oil Co.**, 35 E. Wacker Dr., Chicago, Ill.

Jet fuel 4, $160,200, **Standard Oil Co.** (Kentucky), Starks Bldg., 4th & Walnut St., Louisville 2, Ky.

Jet fuel 4, $2,773,860, **Malco Refineries, Inc.**, PO Box 660 Roswell, N. Mex.

Jet fuel 4, $769,160, **Northwestern Refining Co.**, PO Box 248, St. Paul Park, Minn.

Jet fuel 4, $802,360, **Shamrock Oil & Gas Corp.**, Box 631, Amarillo, Tex.

Jet fuel 4, $56,375, **The Southland Co.**, PO Box 57, Yazoo City, Miss.

Jet fuel 4, $3,141,000, **Wilshire Oil Co. of Calif.**, 727 West Seventh St., Los Angeles 17, Calif.

Jet fuel 4, $16,928,243, **Standard Oil Co. of Calif.**, Western Operations, Inc., 225 Bush St., San Francisco, Calif.

Jet fuel 4, $28,400, **Douglas Oil Co. of Calif.**, PO Box 697 E. Compton Blvd., Paramount, Calif.

Jet fuel 4, $1,611,600, **Bell Oil & Gas Co.**, 1310 National Bank of Tulsa Bldg., Tulsa, Okla.

Jet fuel 4, $120,864, **Caminol Co.**, 525 W. Third St., Hanford, Calif.

Jet fuel 4, $1,848,000, **Cosden Petroleum Co.**, Box 1311, Big Spring, Tex.

Philadelphia Ordnance Dist., 128 N. Broad St., Philadelphia, Pa.

Research study to develop methods for analysis and evaluation of defect data on Redstone missile system, $35,556, **Virginia Polytechnic Institute**, Blacksburg, Va.

Redstone Arsenal, Huntsville, Ala.

Development, manufacture and delivery of TX62 and XM10 rocket engines, $122,482; 18 Falcon rocket engines, $298,561; solid propellant vernier engine, $49,978, **Thiokol Chemical Corp.**, Trenton, N. J.

U. S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Honest John of Verona

Northeast of Verona, at Asiage, Italy, 510th Field Artillery crew prepare to fire ground-to-ground rocket in field demonstration for high ranking NATO personnel.

Instruction and maintenance relative Target Drone, $49,982, **Radioplane Co.**, 8000 Woodley Ave., Van Nuys, Calif.

Field engineering service as related to ground guidance equipment for Corporal Missile, $404,745, **Gilfillan Bros., Inc.**, 1815 Venice Blvd., Los Angeles 6, Calif.

Technical representative for the Ordnance Guided Missile School, $31,858, **Firestone Tire & Rubber Co.**, 2525 Firestone Blvd., Los Angeles 54, Calif.

Missile technical representative services, $48,972, **Douglas Aircraft Co.**, 3000 Ocean Park Blvd., Santa Monica, Calif.

U. S. Army Signal Supply Agency, 225 S. 18 St., Philadelphia 3, Pa.

Research leading to optimum design of missile-air-and-submarine-borne Cesium Beam frequency standard, $155,000, **TRG, Inc.**, New York, N. Y.

NAVY

District Public Works Officer, Sixth Naval Dist. Bldg. 13, U. S. Naval Base, Charleston, S. C.

Power plant expansion and trenching for AF missile test center offshore facilities at Grand Bahama Auxiliary AFB, $74,350, **Nat G. Harrison Overseas Corp.**, 5137 N. E. 2nd Ave., Miami, Fla.

Navy Department, Bureau of Ordnance, Washington 25, D. C.

Pilot production of aluminum rocket motor tubes for Navy's new 5 in. rocket Zuni, $2,000,000, **Hunter-Douglas Div. of Bridgeport Brass Co.**, Riverside, Calif.

Terrier guided missile handling equipment, $217,192, **Burner-Holloman Mfg. Corp.**, Hyattsville, Md.

Experimental shop and test equipment for a new aircraft engine development plant near West Palm Beach, Fla., facility of Pratt & Whitney Aircraft, $28,000,000, **Pratt & Whitney Aircraft**, 400 Main St., East Hartford, Conn.

Navy Dept., Officer in Charge of Construction, Potomac River Naval Command, U. S. Naval Gun Fact., Washington 25, D. C.

Hypervelocity gun range at the Naval Ordnance Laboratory, White Oak, Md., $816,726, **Humphreys and Harding, Inc.**, 527 Barr Bldg., Washington, D. C.

Nuclear Aircraft Laboratory

Funds were allocated to Lockheed's Georgia Div. by the Air Materiel Command to complete basic units of an advanced laboratory for development of nuclear powered aircraft.

The research and development laboratory, which Lockheed Aircraft Corp. is building in the north Georgia mountains on 10,000 acres near Dawsonville, will permit scientists to make vital experiments which cannot be done at any existing nuclear laboratory. The new facility will be known as the Georgia Nuclear Aircraft Laboratory.

American IAF Papers

(CONTINUED FROM PAGE 37)

Most of this information was then neatly tied up in tabular form, from which penetration probabilities could be figured for different satellites. For example, a 20-in. diam satellite sphere having an aluminum or magnesium surface 0.5 mm thick would be penetrated about once every five days, according to Dr. Whipple. Erosion rate for satellite surfaces would be of the order of 2×10^{-13} gm/cm^2/sec or less—unimportant optically for periods under a year, he declared.

The use of satellites as platforms for communication services, like most of the other topics, had been proposed long before General Electric's R. Haviland got to it in Barcelona. But in his paper on the communication satellite, the author went into the problem in some detail "to arrive at the optimum conditions for design and operation of such a service."

Some interesting features of a communication satellite designed for TV broadcast, FM relay, FM broadcast and interstation relay were noted by Haviland: First, it would require a large power supply and a number of antenna reflectors. Then, the system would have to be designed for manned operation on a long term basis. This, in turn, would require synthetic gravity, obtained by rotating the station while at the same time keeping the antennas fixed. To do this, the author suggested that the rotating part of the station be mounted as a wheel on an axle which carries the nonrotating parts.

Would Be Major Undertaking

Size of the communication satellite would probably lie between von Braun's 400-ton, 250-ft diam ring and Romick's 1500-ton, 40 by 500-ft "Second Phase." In any event, declared Haviland, the station would represent a major undertaking, and is clearly beyond the reach of present rocket technology. With nuclear fuels it should be straightforward; with advances in fuel energy, it may become feasible.

In one of the thickest papers (68 pages) scheduled at the Barcelona conclave, authors Darrell Romick, Richard Knight and Samuel Black of Goodyear Aircraft concerned themselves with a manned satellite ferry rocket vehicle. Known as METEOR (Manned Earth-Satellite Terminal evolving from Earth to Orbit ferry Rockets), the concept was first presented in 1950.

From this early study evolved the authors' Barcelona paper, "METEOR JR," a preliminary design investigation for a minimum-sized vehicle similar in conception. As pictured, Junior would be a 500-ton, three-stage vehicle capable of carrying a 1-ton payload plus a crew of two to four persons. It would be "comparable in size, though somewhat larger, than the Atlas ICBM. In a special test configuration, without appreciable payload, the regular final stage could be launched from an Atlas-sized expendable missile." Using existing technology, the authors figured they could achieve their objective in about eight years.

Peter Glaser of Arthur D. Little, Inc., deviated noticeably from the subject of space vehicles, and chose instead to talk about high temperature research, a subject of rapidly growing interest to missile men.

The reason for this interest, of course, is not hard to find. As the author pointed out in his introduction, "we need a great deal of such (high temperature) data to improve current designs for missile skins, gas turbines, rocket motors, and nuclear applications, and to establish criteria for materials that will ultimately spearhead thermonuclear-power developments."

Once into his subject, Glaser treated it in the order of rising temperature limits. Starting with electrical methods, the induction and resistant furnaces and a 3900 C limit, he went quickly to electromagnetic radiation, the solar furnace and high-intensity electric arcs and top temperatures of about 4500 C.

The author paused on chemical sources only long enough to note that the aluminum "skating sun" method seems to be the most promising. Here, the molten metal floats on the liquid oxide, burning in an atmosphere of oxygen with a brightness temperature of 3200 K.

Methods of heating gases by shock waves (to 18,000 K) and electric arc discharges (to 50,000 K) were given perhaps the most detailed treatment. In closing, Glaser took a look at the future, noted that generation of gas temperatures close to 1,000,000 K had already been reported, and looked forward optimistically to the time when thermonuclear reactions will be controlled and "continuously controllable."

There were a number of other Barcelona papers. Many concerned topics already mentioned; others dealt with subjects such as the roles of balloons and ballistic missiles in astronautical research.

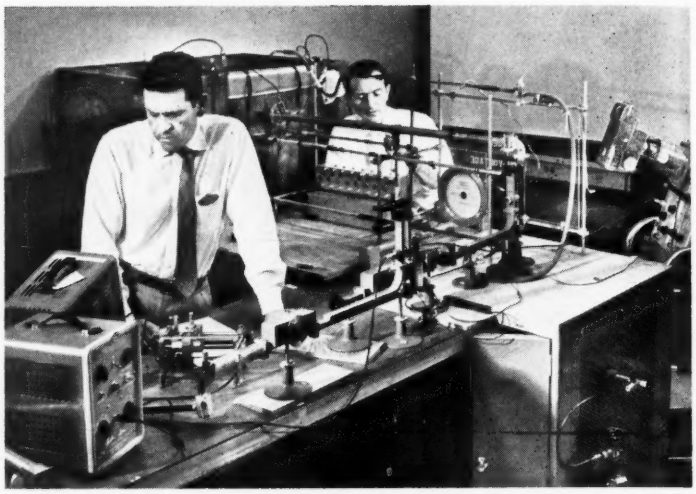
A brief listing of the American papers presented at the meeting, along with ARS preprint numbers, follows:

Maj. Gen. H. N. Toftoy, "U. S. Army Support of Scientific Activities in Astronautics" (505-57).

Col. W. O. Davis, "Research Goals in Astronautics" (506-57).

K. A. Ehricke, "Instrumented Comets—

Lockheed Hits 100,000 C



Lockheed Missile Systems scientists check their new hydromagnetic shock tube. Reportedly the forerunner of other shock tubes now under development, the unit is capable of creating velocities above 100,000 mph and temperatures above 100,000 C.

Astronautics of Solar and Planetary Probes" (493-57).

C. Gazley Jr. and D. J. Masson, "Recovery of a Circumlunar Instrument Carrier" (488-57).

S. Gerathewohl et al., "Producing the Weightless State in Jet Aircraft" (503-57).

P. E. Glaser, "On the Generation of Temperatures to 30,000 K" (495-57).

F. G. Gravalos, "A Method of Integrating the Equations of Motion of a Body Entering an Arbitrary Atmosphere with an Automatic Error Analysis" (507-57).

A. G. Haley, "Space Law—The Development of Jurisdictional Concepts" (508-57).

R. Haviland, "The Communications Satellite" (487-57).

S. Herrick, R. M. L. Baker and C. G. Hilton, "Gravitational and Related Constants for Accurate Space Navigation" (497-57).

A. Hynek and F. L. Whipple, "Optical and Visual Tracking of Artificial Satellites" (500-57).

W. B. Klemperer and E. T. Benedikt, "Selenoid Satellites" (486-57).

H. H. Koelle, "Optimization Considerations for Orbital Payload Capabilities" (491-57).

E. R. Manring and J. F. Bedinger, "Sodium Emission at 140 Km" (496-57).

A. Miele, "Optimum Burning Program as Related to Aerodynamic Heating for a Missile Traversing the Earth's Atmosphere" (494-57).

R. T. Patterson, "Vertical Recovery—Feasibility of the Physical Recovery of Scientific-Research Payloads from Very-High-Altitude, Near-Vertical Trajectories" (489-57).

R. E. Roberson, "Altitude Control of a Satellite" (485-57).

D. C. Romick et al., "Meteor Jr., A Preliminary Design Investigation of a Minimum Sized Ferry Rocket Vehicle of the Meteor Concept" (504-57).

I. Schmidt, "Visibility of Artificial Satellites" (498-57).

Major D. Simons, M.D., "Application of Satellorb" (502-57).

S. F. Singer, "Interplanetary Ballistic Missiles—A New Astrophysical Research Tool" (492-57).

E. Stuhlinger, "Design and Performance Data of Space Ships with Ionic Propulsion Systems" (509-57).

F. L. Whipple, "The Meteor Hazard to Space Vehicles" (499-57).

Otto C. Winzen, "10 Years of Plastic Balloons" (490-57).

Papers were also presented by members of several other delegations to the Congress. Among these were the following:

Brazil—Thomas Bún and F. A. Pereira, "'Biospheric Index,' A Contribution to the Problem of Determination of Extra-Solar Planetary Biospheres' Existence," and Sociedada Interplanetária Brasiliera, "Contribution to the Problem of Space Law Establishing a Technical and Practical Limit to Political Sovereignty in Height."

France—J. J. Barré, "Essai de Contribution à la Propulsion Ionique" and "Essai de Contribution à l'Autopropulsion Nucléaire," and H. Gutton, "Pilotage d'un Astronef par des Moyens Radioélectriques."

Great Britain—W. N. Neat, "The Problem of Variable Thrust."

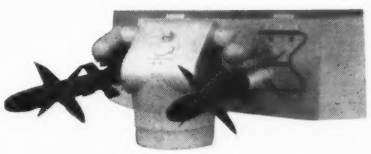
Holland—J. M. J. Kooy, "On Relativistic Rocket Mechanics."

Italy—C. E. Cremona, "Previsione Tempestiva delle Caractteristiche del Moto di Mobili Aero-Ballistici nella Cibernetica Aeronautica," and Alessandro Boni, "Rilevamento di un Satellite presso la Culminazione."

Poland—M. Subotowicz, "Einige Optimalisationsprobleme der Theorie der Stufenraketen und ein Einfaches Verfahren der Erminttlung der Optimalen Parameter der Stufenrakete," and Jan Gadomski, "Die Sternekosphären im Radius von 17 Lichtjahren um die Sonne."

Switzerland—Björn Bergqvist, "The Weight of Minimum-Cost Orbital Ferry Vehicles."

Talos Ready for the Fleet



Handling the Talos: Once fire control decides, the rest is automatic.

Loading and launching of the Talos will be handled by a complex system weighing more than 350 tons. The system automatically selects the type of missile (high explosive or atomic warhead) the fire control officer chooses, loads it, trains it, elevates it, and, finally, launches it.

Guidance of the surface-to-air missile will be carried out by new high performance radar, announced in the Spring by Sperry Gyroscope and the Navy. When first revealed (JET PROPULSION, June, p. 705), the "super-radar" was said to be used in conjunction with Terrier surface-to-air missiles.

Both air defense missiles are shipboard weapons which ride beams to targets. The new radar, antennas which resemble giant searchlights, has exceptional power which adds many miles to its beyond-horizon range. The Terrier guidance system is designated SPQ-5; Talos' system is SPG-49.

Talos, a ramjet powered weapon with supersonic capabilities, is major armament for the cruiser USS Galveston and others. Terriers are aboard the cruisers Canberra, Boston and others.

UCLA to Offer Course In Space Technology

The University of California at Los Angeles will offer a full-scale course in Space Technology beginning in January. Coordinator of the course is Howard S. Seifert, Guided Missile Research Div., Ramo-Wooldridge Corp., and visiting professor of engineering at UCLA.

The course will run from Jan. 13 to May 19, with $2^1/_2$-hour lectures given one evening each week. The roster of lecturers, two of whom will speak at each session, reads like a "Who's Who" of the astronautical sciences, including, among many others, Joseph Kaplan, Hubertus Strughold, James Van Allen, Wernher von Braun, Krafft Ehricke, W. H. Pickering, J. W. Siry and Alfred A. Eggers.

The course will be on the first year graduate level, and all students will have technical degrees. It will span the entire spectrum of space flight, covering such subjects as flight dynamics, propulsion, structures, communications, guidance, space medicine, human factors and scientific uses of space vehicles.

On May 12, Simon Ramo of Ramo-Wooldridge Corp., H. Guyford Stever of MIT, A. Kantrowitz of AVCO and Richard W. Porter of General Electric Co. will participate in a panel discussion on future problems and progress in space technology. A final examination will wind up the course the following week.

Each lecture will be given in three cities—Los Angeles, San Diego and the San Francisco Bay area.

IR Symposium

The first nation-wide Infrared Information Symposium (IRIS) was held Oct. 1–4 at the Huntington-Sheraton Hotel in Pasadena, Calif.

Office of Naval Research sponsored the meeting for all the military services. (Nearly all current work on military infrared physics and technology is related to aircraft and missiles.)

Approximately 500 scientists, military service representatives, and representatives of firms engaged in development and manufacture of infrared devices attended. Admission to the symposium was by invitation only. Papers and discussion were classified secret and stringent security measures governed access to the meetings.

Personnel of the Avionics Div. of the Aerojet-General Corp., with infrared research laboratories and manufacturing facilities at nearby Azusa, assisted ONR in making preparations for the meeting.

Check-out on Atlas

At March AFB, Airman R. V. Petty is checked out on procedure for fueling Atlas ICBM. Petty was one of 16 AF specialists put through this simulated fueling situation by Convair as part of its human engineering study to determine the most nearly foolproof arrangement for actual operating conditions.

Weightlessness

(CONTINUED FROM PAGE 34)

By utilizing his thrust for eliminating drag, he kept the airplane on its parabolic course until the pull-out was started early enough to prevent the aircraft from passing its Mach limit and the aforementioned gravitationally normalized force (GNF). In this pattern, the force acting upon the body never exceeded 1.5 g and the subjective experience of increased weight was slight or not even noticed by the subject because of the slow rate of change of acceleration.

The second flight pattern consisted of a series of three parabolas in a row. At 20,000 ft a sharp dive was started and the aircraft nosed down at an angle of about 65 deg. Then the plane was pulled out rather abruptly, resulting in 3 g acceleration. With a higher climbing speed available, a longer parabolic arc was obtained. Recovery at 17,000 ft provided the necessary speed for the upswing into the next parabola. In this maneuver, the individual was subjected to a sequence of relatively high and sharp increases of weight and longer periods of virtual weightlessness than in the first phase of the experiment.

The test subject, riding in the rear seat of the T-33 or F-94, was told that he was to furnish information about his subjective experience of weightlessness during the flights. He was to keep his eyes open during the first parabola, close them during the second one, let an object and his arms float during the third, and to look outside during the fourth maneuver. If he felt comfortable but was not aware of any peculiar sensations, the pilot would repeat the maneuver at his request. If he became sick or felt uncomfortable, he would be flown back immediately.

After a short period of straight-and-level flight, the second flight pattern was to be started. The subject was told to compare this experience with the previous one. In addition, he was told to shake his head slowly in the horizontal and vertical plane during the last parabola, and to direct his attention to the occurrence of Coriolis effects and vertigo. In the event of nausea, dizziness and similar symptoms of motion sickness, the subject was to search for the cause of these untoward effects, i.e., to find out when and under what conditions they occurred. Was the feeling of unpleasantness enhanced during weightlessness or during the pull-out? Was it affected by visual stimuli?

The subject communicated his experiences to the pilot, who, in return, announced all maneuvers in advance. The latter also furnished a written report concerning weather, flight, turbulence, unusual events and the subject's responses to the various maneuvers. In the last phase of the experiment, communication between pilot and subject was tape-recorded.

Described His Experiences

Before each flight, the subject was informed he would have to render a written report of his experiences during periods of weightlessness. He was asked after landing to describe rather casually his experiences, including such phenomena as fall tendency or sensation, apprehension, anxiety, excitement and other emotional responses. In case of motion sickness attacks, he was to give exact statements concerning his emotional and mental state, degree of disorientation and incoordination, origin of disturbance (stomach or head), kind and variety of symptoms and distress. Furthermore, the flight surgeon who saw the subject before and after the flight recorded behavioral changes at the flight line. Finally, all abnormally responding subjects underwent an extensive interview by this investigator after the flight. After all the data had been collected, they were evaluated with regard to the mode of personal response and tolerance to weightlessness.

Thus far, 47 individuals have participated in these experiments, and their responses to weightlessness studied. Reactions of test subjects were highly individualistic. While about half the subjects felt very comfortable during weightlessness, and reported no sensations of motion other than a slight elation associated with the feeling of exhilaration and pleasantness, several others described sensations of motion with no emotional involvement. A third group of subjects experienced discomfort, nausea and severe symptoms of motion sickness. A table showing the distribution of the 47 subjects tested with regard to the three groups of behavior is found on page 34.

Marked Differences Found

There were some marked differences among subjects with regard to motivation and stress. The subjects cannot be considered a random sample of the world's population because of the high physical and psychological standards required for jet flying, the previous flying experience most of them had, and their high motivation. Seventeen of the subjects were either AF pilots or had at least some flying training; only nine had no jet experience prior to the experiment; and all had flown at least once in conventional aircraft. Their ages ranged from 20 to 46 years. There were 46 males and one female in the group. All volunteered for the experiment, only a few dropped out during the tests, and some repeated the experiment several times despite severe attacks of motion sickness.

Subjective symptoms prior to flight consisted mostly of a moderate apprehension and mild tension or nervousness. While the experienced jet fliers were generally found to be free of symptoms, some of the neophytes reported moderate fear and anxiety before take-off and during first exposure to weightlessness. These symptoms were frequently followed by psychomatic and autonomic disturbances in the latter phase of the flight. In some cases, subjects were apprehensive because of known proneness to motion sickness, and therefore anticipated discomfort during the parabolas.

The question exists as to whether and to what extent the attitude of the subject contributed to the occurrence of motion sickness symptoms during weightlessness, but there is some evidence of a direct relationship between the "set" of the subject and his tolerance to the agravic state. The least we can say is that apprehension, fear and acute anxiety occurred concomitant with psychosomatic disturbances.

Practically all subjects reported sensations of floating or slowly drifting during lack of appression. Members of Group I associated these sensations primarily with feelings of comfort, pleasure and exhilaration. On

the other hand, members of the second group described rather vividly sensations of tumbling, falling, rolling over, standing on their heads or being suspended in mid-air in an inverted position. They also reported a definite sensation of lift during the transition from increased or normal GNF into weightlessness. Most of these subjects reported the sensations of motion without emotional involvement. They described the situation as neither unduly pleasant nor particularly disagreeable, and they concluded that in general the weightless condition produced "not exactly a comfortable feeling."

Within the third group, sensations of floating, falling and drifting were also reported. Some members of this group felt quite comfortable at the beginning of the experiment but experienced increasing strain and discomfort as the experiment progressed. In some cases, the situation appeared unreal. Attempts to prevent the approaching attack of nausea were unsuccessful.

Several of the subjects in Groups II and III reported sensations of motion and posture which differed considerably from the actual condition. They also stated they were completely disorientated when they had their eyes closed during the agravic state. This type of loss of reference is in accord with the concept that motion sickness is more often caused by the incapability of the brain to handle the incoming messages properly than by overstimulation. Hence we may conclude that the motion sickness syndrome associated with lack of appression was produced in some cases by sensory inconsistencies and the final breakdown of the subject's scheme of orientation.

When we speak of the tolerance of an individual to something, we usually mean the ability to maintain his performance level under a certain type of stress. Actually, weightlessness does not seem to exert physical stress upon the individual. On the contrary, all weight and burden of physical matter is removed in this state. However, weightlessness is not at all a psychophysiological state that is equally enjoyed as a pleasant experience by all persons exposed to it. Our findings show it exerts a certain load of emotional stress and, most probably, causes an alteration of sensory input which may account for the observed psychophysiological disturbances.

Numerically, about 30 per cent of our subjects reported severe autonomic disturbances which were attributed to the effect of weightlessness. Some showed improvement on repeated flights but still became sick during the third experimental flight. Reasons for the untoward effects are unknown. If changes of the GNF are the cause, transition from one state into another will be critical, but no detrimental effects are to be expected in the weightless state. If hypersensitivity to unusual stimulation brings forth the syndrome, prolonged states of weightlessness may be intolerable. Upon these premises, one can suppose that the first group can endure longer periods of weightlessness without untoward effects, whereas members of the last group will not be capable of maintaining their efficiency during the weightless condition.

There is some evidence from our findings that flying experience and conditioning prior to the exposure to lack of appression affect tolerance to weightlessness, and that pilots of jet aircraft are best suited for operations under conditions of reduced appression and weight. Since about one-third of our subjects developed untoward effects which reflected unfavorable upon their attitude, motivation and task performance, a careful selection of future rocket fliers and proper conditioning of passengers of rocket ships, manned satellites or space craft, seems mandatory when such vehicles come to be built.

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EQUIPMENT

Missile Tracking Camera: Greater magnification and high resolution provided by the Model V 70 mm missile tracking camera permit accurate data recording well beyond the capabilities of cameras using smaller film sizes. The $2^1/_4 \times 2^1/_4$ in. frame size minimizes the effect of tracking error, and helps keep the missile image within the frame. It provides close-up views for accurate pictures of fin flutter, exhaust nozzle characteristics and other component details. Flight Research, Inc., P. O. Box 1-F, Richmond 1, Va.

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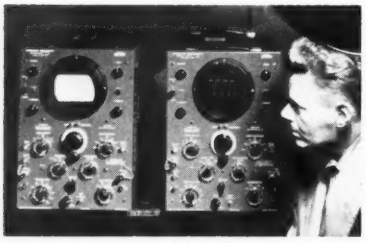

Black Screen for Radar: A special black background screen for radar and other visual electronic indicators, which eliminates limitations of such equipment under high surrounding light level conditions, has been developed by Du Mont. High light levels tend to "wash out" the image on a cathode ray tube screen due to the absence of contrast between what is being viewed and the background on the tube face. The new screen creates the same contrast that might be attained with a "black phosphor." Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J.

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Power Oscillator: For pre-flight missile system checkouts, precision 400 cycle gyro testing, time correlation work and as special power sources for critical requirements, Elin precision power oscillators may be obtained in the cabinet model (DK-102) or rack model (DK-102R). When desired, fast conversion from cabinet model to rack installation is made possible with a control panel kit which fits standard rack mountings. Precision stability is derived from a High-Q LC tuned circuit and voltage-sensitive bridge combined in a circuit employing a large amount of negative feedback. Electronics International Co., 145 W. Magnolia Blvd., Burbank, Calif.

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Diaphragm Seals: For aircraft, missiles and rockets, diaphragm seals fabricated from fabrics such as Nylon, Dacron and fiber glass, and coated with silicones and other common elastomers, are now available in thicknesses of 0.010 and 0.018-in. The seals, produced to customer's performance and design requirements, are suitable for experimental or prototype use, as well as long or short run production. Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif.

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Push-Button Actuator: Designed to accept any one of three standard basic switches without altering the actuator bracket, the manually operated A4-67 actuator permits a wide range of circuit arrangements from SPST to TPDT six-circuit. The actuator button is housed in an independent threaded bushing unit which screws into the bracket and acts as an adjustment for panel thickness variations and as a lock nut for panel mounting. Electro Snap Switch & Mfg. Co., 4218 W. Lake St., Chicago 24, Ill.

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Thread Sealing: Lox Safe thread sealing compound has an almost negligible impact sensitivity in liquid oxygen systems. The material, packaged in 2 and 4 oz. metal tubes, has been approved under several rocket motor manufacturer's specifications. Redel Inc., 220 N. Atchison St., Anaheim, Calif.

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Tantalum Capacitors: For high temperature applications in missile guidance systems and other uses involving critical environment, tantalum capacitors are available on a shortened delivery schedule. Stepped-up delivery applies to all Mallory tantalum grades for military use at temperatures up to 175 C, and subminiature types for 85 C operation in transistor applications and other miniature circuits. P. R. Mallory & Co. Inc., Indianapolis 6, Ind.

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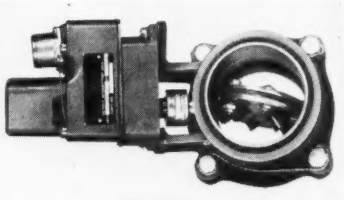

Shut-Off Valve: A line mounted butterfly type shut-off valve for systems handling aviation fuels has been proved for operation at ambients from −665 F to +265 C. The unit for a $2^1/_2$ in. line weighs 3.2 lb. Its operation may be controlled electrically, hydraulically, pneumatically or manually. Aero Supply Mfg. Co. Inc., Corry, Pa.

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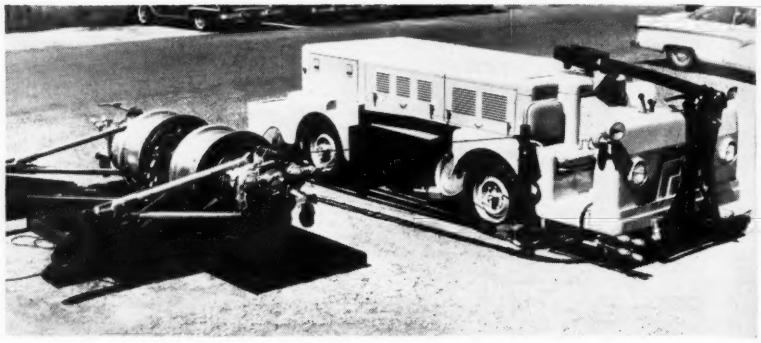
Elapsed Time Indicator: A miniature shock-resistant elapsed time indicator operates on 28 d.c., and meets military requirements. It supplies information in connection with airborne



Mobile Power Wheel-Mover

A power vehicle with wheel-mover units for ground servicing and ground movement of airline jet aircraft was demonstrated recently in a test rig. Using a B-52 landing gear with brakes set to simulate the weight load of the aircraft, Con Diesel's wheel-mover transmits driving power to the wheel rims at speeds up to 5 mph, forward and reverse, with braking power equivalent to 200,000 lb of inert weight. Control of speed and direction of each wheel is maintained by a small remote handset which would be handled by the aircraft pilot. Production versions are scheduled for delivery in mid-1958. Consolidated Diesel Electric Corp., Stamford, Conn.

computers, bombing systems, flight recorders and similar types of electronic equipment. The unit is $^{7}/_{8}$ in. diam by $1^{1}/_{8}$ in. long, with plug-in electrical connections for standard crystal socket. Two hands indicate elapsed time up to 2500 hours, after which the cycle is repeated. The E. Ingraham Co., Bristol, Conn.

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Vibration System: Utilizing a new principle of electronically controlled hydraulic power, the "Wyle Hydrashaker" vibration excitation system provides previously unattainable combinations of force, acceleration and frequency to produce realistic simulation of missile and aircraft operating environments. Three basic units comprising the system are: Control console which integrates all electronic equipment and controls, power supply unit for conversion of electrical power to hydraulic power, and small 75 lb exciter unit. Wyle Manufacturing Corp., 124 Maryland St., El Segundo, Calif.

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Rugged Accelerometer: The potentiometer type Garrett accelerometer operates on a silicone damped spring-mass system. Designed for uses in the −65 F to 350 F range, its spring has a zero thermoelastic coefficient. The accelerometers are built in 1 to 10 g models, and are replaceable without need for adjustment or calibration of associated equipment. AiResearch Mfg., Div. of The Garrett Corp., Phoenix, Ariz.

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Missile-Borne Sequencer: Designed as an operationally flexible switching device for missile applications, a motor-driven sequencer has operated in two sounding rocket programs. It is used for ignition of rocket motors, flares, starting of missile-borne recording equipment, and sequencing of internal instrumentation calibration signals. The switching system consists of a miniaturized d-c motor attached to a planetary gear box which rotates a wiper arm across equally spaced contacts on a printed circuit. It operates during and after acceleration loads in excess of 100 g, and functions at altitudes above 100,000 ft. Era Engineering, Inc., 1009 Montana Ave., Santa Monica, Calif.

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Cheaper Stainless Sheet: Chromalloy-Stainless can replace type 430 and its cost is less. The new sheet, which withstands operating temperatures of 1200 F indefinitely and 1500 F for hundreds of hours, is produced by a chromizing method. Through high temperature diffusion of chromium into the 1010 steel, a stainless surface is formed. It is produced in sizes up to 2 ft × 5 ft and gages 16 to 24. Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y.

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Silicone Rubber: Designated SE-555, a silicone rubber strong enough to replace organic rubber is available in commercial quantities. The compound is suited for aircraft seals and gaskets for use in the −150 to 500 F range.

Physical properties include 1600 psi tensile strength; 650 to 850 per cent elongation; and 200 to 250 lb/in. tear strength. Silicone Products Dept., General Electric Company, Waterford, N. Y.

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Blind Bolts: Designed for applications where the work is accessible from only one side, such as tanks, etc. the Blind Bolt is a simple three piece fastener. It consists of a core bolt, a threaded expander nut which resists installation torque and locks the core bolt in place, and a sleeve which expands to fill and seal a hole. The bolt is corrosion-resistant and tests were conducted on a stainless steel pressure tank for propellants to determine long-time acid exposure and assure their reliability in applications in which they will be subjected to an acid vapor atmosphere. Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif.

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Miniature Inertia Switch: Used for aircraft, missiles and electronic components, Model 510, smallest known inertia switch, operates by a new, simple principle. One single moving part, frictionless in operation, momentarily closes electrical contacts, following impact or acceleration above a preset value. Switch setting adjustable from 1.5 g up; tolerance ±0.15; volume $^{1}/_{2}$ cu in.; weight $^{3}/_{4}$ oz. Safe Lighting, Inc., 527 Lexington Ave., New York 17, N. Y.

PRODUCT LITERATURE

Age of Space. Proceedings of a nontechnical conference on missiles, rockets and space travel sponsored by the Southern Research Institute are given in a new booklet, including the eight addresses given before a group of 350 businessmen last May. Southern Research Institute, Birmingham 5, Ala.

Epoxy Resins. A 7000-word booklet discusses epoxy resin compounds. The booklet features complete tabulation of physical and electrical properties for nine different potting resins, as well as graphs of properties of more than 40 different compounds and curing agents. Booklet is a combination catalog and research report. Single copies are available when requested on company letterhead. Dr. Henry L. Lee, The Epoxylite Corp., 10829 East Central Ave., El Monte, Calif.

Valve Position Indicator. Position indicators that automatically signal a control board apparatus when the opening or closing cycle has been completed are described in an illustrated bulletin. Two models are offered: a single-pole double-throw switch weighing less than 0.1 lb, and a double-pole double-throw unit weighing 0.19 lb. Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.

Nylon Wire Clamps. A four-page folder describing a fast, lightweight way to secure wires in aircraft and missile assemblies details the application, holding power, and modification of nylon wire clamps. Outline drawings and tables give dimensions and specifications of types available. Dakota Engineering, Inc., 6641 Crenshaw Blvd., Los Angeles 43, Calif.

Quick-Disconnect Connectors. Bulletin PR-Q describes the "Q" quick-disconnect series of connectors available in three sizes with three shell configurations: A square-flanged receptacle, a hermetically sealed round-flange receptacle, and a straight plug.

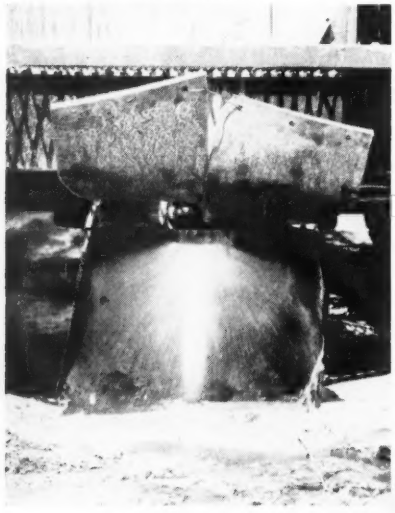
Resilient grommets on the back of the receptacle and plug have internal restrictions which will seal an 0.050 o.d. to 0.105 o.d. range of wire sizes. Receptacles have a rubber sealing ring forward of the insert face. Cannon Electric, 3208 Humboldt St., Los Angeles 31, Calif.

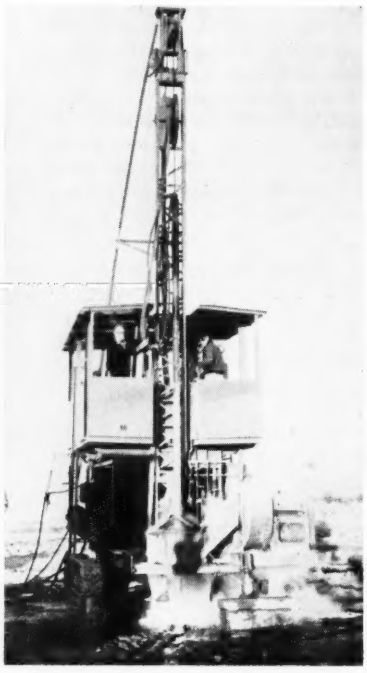
Automatic Timing. A new line of time delay relays and sequence program switches is described in Engineering Data Sheet No. 5. Applications, operation, and specifications with illustrations are given in the four-page description of two basic types of timers. Diagrams show a typical

repeat cycle with up to six available load circuits and a typical reset cycle with up to five load circuits. Automatic Timing & Controls, Inc., King of Prussia, Pa.

Inert Gas Generators. The Sub-X line of inert gas generators utilizes direct contact cooling of the products of combustion from a thermal high velocity burner and the resulting design is attractive from a cost and size standpoint. A wide range of standard models is available using either gas or oil as the fuel. Multiple burner units can be offered for very large capacity requirements. Bulletin 114 describes the units, giving capacities, dimensions and operating details. Thermal Research & Engineering Corp., Conshohocken, Pa.

Jet Propulsion Goes Commercial





Rock Tenderizer: Jet-Piercing rig eats through stone in a flash.

Three million tons of rock are being removed from a St. Lawrence Seaway lock near Melocheville, Quebec, by a new industrial flame process called Jet-Piercing (ASTRONAUTICS, Oct., p. 5). The new process, working on the jet principle, reportedly pierces rock at speeds 10 times faster than conventional drilling methods.

Supersonic jets of flame are the key to the process which was developed by Linde Co., Div. of Union Carbide Corp. Traveling five times faster than the speed of sound and reaching temperatures of 4000 F, the flame spits out of a rocket-type burner and disintegrates the rock in its path in a continuous operation. Rock particles are thrown up out of the hole by the combined force of burning gases and steam so that a fresh surface is continually exposed to the jet flame.

The only limitation to penetration depth is the length of hoses lowered into the hole to carry fuel, oxygen and water. Deepest penetration obtained to date is 160 ft. At its highest velocity, the flame has a mechanical energy equivalent of about 500 hp, and is contained in a flame not more than 18 in. long and 2 in. wide.

Low viscosity fuel oil or a liquid hydrocarbon fuel such as kerosene is combined with high-purity oxygen to produce the intensely hot flame. A blowpipe suspended from a crawler carrier controls flame combustion and action.

The new process works fastest on the class of spallable rocks which normal drilling methods find toughest—especially those containing silica—such as granite, syenite, quartzite, sandstone and magnetic taconite. Potsdam sandstone, the rock being pierced on the St. Lawrence Seaway, is a highly abrasive material that would normally cause excessive bit wear. In the past it has taken as long as a week to drill a 100-ft hole in this very hard rock using churn drills. But with Jet-Piercing, a 100-ft hole reportedly can be sunk in a single shift.

Boral Shielding. A four-page folder on boral for neutron shielding is available from the first industry producer of boral for use in atomic power installations. The folder describes its composition, many uses, and shielding properties. Brooks & Perkins, Inc., 1950 W. Fort St., Detroit 16, Mich.

Capabilities Report. Sylvania lists capabilities, projects and products of its Electronic Systems Division in a 12-page report. The Division will seek business only within areas of established competence in defensive missile systems, electronic warfare systems, data processing systems, and related equipment and components. Capabilities cited in the report include system or subsystem management, system analysis, research and development, product engineering and manufacturing. Electronic Systems Div., Sylvania Electric Products Inc., 100 First Ave., Waltham, Mass.

ICBM Design Study Goes to Aeronca

Aeronca Manufacturing Corp. got a subcontract from Convair-Astronautics Div. of General Dynamics Corp. for research on materials to be used in the design and fabrication of the Atlas intercontinental ballistic missile.

The missile currently is in pilot production at the San Diego factory of the Convair Div.

Radar Developments

A radar patent has been granted to retired Signal Corps scientist, Col. William R. Blair, who conceived the pulse-echo method of direction finding and ranging before 1930. Patent application, due to secrecy, was not filed until 1945.

Army has developed a new electron tube, the "amplitron," which can increase the power in the radar defense networks and generate basic radar waves. Lighter radar units are expected to result. The tube is reportedly twice as efficient as earlier tubes and, at the same time, capable of boosting basic signal output eight to 14 times.

Two Companies Merging

The merger of the Liquid Carbonic Corp. into General Dynamics Corp., subject to approval of the stockholders of both companies, was approved by the directors of the two firms. Liquid Carbonic is the world's fourth largest producer of oxygen. But General Dynamics claims the move on its part is strictly for diversification and has no tie-in to its missile activities.

Bricks to Rascals

(CONTINUED FROM PAGE 45)

theless, there have been some new developments in the U. S. air-to-surface missile field. Among the more significant:

• Zuni, a recent development, is the first new unguided rocket to enter service in some time. It is reported to have twice the performance of the older HVAR.

• Bullpup, a short-range air-to-surface guided missile developed by Martin for the Navy, is not yet in service. Designed for launching from fighter aircraft, the missile is about 11 ft long and weighs under 600 lb. It is powered by a solid propellant engine, features an active tracking system and movable canard controls.

• Petrel, a Fairchild-Navy development, is nothing more than a standard MK-13 torpedo around which an airframe has been built. Powered by a 100-lb-thrust J-44 turbojet, the Petrel has a range of about 20 miles and features an underwater radar homing device. It is 24 ft long, 2 ft in diam and has cruciform wings. The Kingfisher and Grebs served as precursors for the missile. Petrel is no longer in production and is, presumably, obsolete.

• Dove, another Navy project that may have been suspended, is the antiship missile developed by Eastman Kodak. It is reported to have an autopilot and infrared seeker system. Little else is known about the missile.

• Rascal, the modern guided powered bomb, is reportedly the U. S.'s most advanced air-to-surface missile. It has a reported velocity of Mach 1.5, produced by three in-line liquid propellant (acid-gasoline) motors. Extensively tested at Holloman Air Development Center, the Bell missile is designed for launching from B-36 and B-47 type bombers. Its 100-mile-plus range makes it useful against both strategic and tactical targets. Rascal probably uses an inertial guidance system. It is not known whether terminal commands are given or not. Likely armament is a pre-set atomic warhead.

Not Too Common Today

The long-range air-launched missile is not too common today. The British are reportedly developing one for use with the V-class jet bombers, and the Russians also probably have something in this field.

When the specifications for Rascal were set down, launching 100 miles from the target may have seemed quite attractive. Today, however, this may not be quite enough. Rascal, with its Mach 1.5 velocity and long trajectory, may be relatively easy to intercept. Advanced versions of Nike, Talos and Bomarc are designed to reach into the precise area where a B-47 would be preparing to drop the Rascal.

This is not to suggest that launching 100 miles away from the target is not preferable to launching 20 miles out, but with rapid advances in weapons systems, tactical and strategic planners are bound to ask questions about the ultimate effectiveness of a B-47 and Rascal system.

What Will Follow Rascal?

As ground-launched missiles assigned to point and area defense become more efficient and F-102 and F-104 aircraft production increases, one may well speculate as to the weapon that will eventually supersede Rascal.

That military planners are fully cognizant of the importance of developing longer-range air-to-surface missiles was indicated recently by the announcement of an Air Force development contract award to North American Aviation for an ASM with a range considerably beyond that of the Rascal. The new missile, intended for use with B-52 bombers, has been placed on a high priority list.

While we've come a long way since the days when World War I pilots dropped bricks on enemy troops, there can be little doubt that air-to-surface missiles are still in their infancy. Tomorrow may see the development of long-range missiles that will make the Rascal, today the last word in ASM's, look almost like a child's toy.

Spotlight on Satellites

(CONTINUED FROM PAGE 50)

Colo., on sun-earth relationships; John A. Simpson, professor of physics at the University of Chicago, on cosmic radiation and geomagnetism; Robert A. Helliwell, professor of electrical engineering at Stanford University, on the upper atmosphere; and Farrington Daniels, professor of chemistry at the University of Wisconsin, on the chemical implications of the IGY. All but the last are associated with USNC-IGY.

Along with the symposium, the Planetarium presented an imposing exhibit, highlighted by a full-scale Viking rocket cut away to allow inspection of internal parts and dynamic representations of satellite orbits and upper atmosphere phenomena.

USAF Announces First Ballistic Missile Division

Activation of the Air Force's first Ballistic missile division headquarters at Cooke AFB, Lompoc, Calif., was announced by Lt. Gen. Samuel E. Anderson, Commander, ARDC, Baltimore, Md. Known as the 1st Missile Division, the unit, commanded by Col. Wm. A. Sheppard, will have over-all supervision of the AF ballistic missile training program, and of establishing initial operational capability.

Previously, the AF announced activation of the 704th Strategic Missile Wing at Cooke AFB. The Wing, along with the other future units, will be directed by the 1st Missile Div. Primary mission of Cooke AFB will be training of ballistic missile units. Cooke will have an operational capability as a seconadry mission.

Baked Radomes

Gladding, McBean & Co., Los Angeles, recently completed the first 10 prototype high alumina ceramic radomes under an Air Research and Development contract, and, thereby, may have opened the door to a new market for the ceramic industry.

Present radomes, normally made of reinforced plastic, have a tendency to char and lose their strength when subjected to extreme heat, particularly that encountered by missiles upon reentry into the atmosphere, according to ARDC. This is the reason for the Air Force's interest in the development of new radome materials.

Starting out as a mixture of high purity alumina and organic binder, the new radomes consist of 97 per cent alumina in their final form. The processing in-between is, briefly, as follows:

Aluminum oxide and binder are made into a slurry about the viscosity of cream. The slurry is sprayed on a chrome-plated steel mandrel with a special spray gun and dried. The unit is then covered with a neoprene bag, placed in a specially designed pressure vessel, and subjected to 30,000 psi. (This is accomplished by feeding glycerol to the vessel with a high pressure hydraulic pump.)

Following this compacting, the radome is stripped from the mandrel and fired at 2200 to 2250 F. Using a diamond tool, workers next machine it on a lathe to the desired wall thickness, then give it a final firing above 3000 F in a regenerative kiln.

The result is a prototype radome 6 in. across and 18 in. high. The process, Gladding, McBean points out, is suitable to the production of larger radomes.

Flying Missiles on the Ground

(CONTINUED FROM PAGE 47)

three-dimensional flight simulator, in which the table is mounted on three gimbals, giving motions in roll, pitch and yaw. High frequency response amounts to a natural frequency of approximately 100 c/s in roll and 40 c/s in pitch and yaw.

The table has a hydraulic drive system which may be operated up to 3000 psi pressure. Basic feedback from each axis is obtained from tachometer pick-offs. Electrical connections to the table are made through slip rings on each axis.

Operation of the table is controlled by signals from an analog computer housed in an adjoining room. The computer consists of two main sections, a D-C part which is associated with the analogs from the table and an A-C section which operates the servos and provides modulators and demodulators. Multiplication and division is possible by means of electronic multipliers, designed to give the wide band widths needed for accurate solution of the equations of motion.

Simplifies the Job

Removable program boards are not presently available with the equipment now in use at Autonetics. However, a later version of the computer does contain removable plug boards. Through their use, a problem is set up on a program board and, when flight simulation has been completed, the board can be removed from the computer for storage. Then, when the computer has to run through a similar problem, it is a simple job to reinsert the plug board, since it is not necessary to go through the time-consuming task of setting up the jumper wires all over again.

At Downey, the table is used in two main areas, Harold L. Ehlers, supervisor of the analysis and flight simulation group, and responsible for operation of the facility, explained.

The first area of utilization is for the comprehensive closed-loop type of study. The flight table imparts a rotational motion to the actual elements used in a flight control system. The aerodynamics and kinematics are simulated by means of the auxiliary analog computer. Such tests not only evaluate the suitability of over-all system design and actual hardware performance under the most realistic conditions, but also reproduce all the events leading up to actual in-flight failures.

The table takes up the orientation which a missile would have in flight, so that a model mounted on the table goes through the angular motions which a real missile would follow in its flight. Hardware, such as gyros for a control system, can be mounted on the table so that their outputs are fed into the computer. The effects on the missile's path during all possible maneuvers and flight conditions can thus be determined.

Because the computer simulates the six degrees of freedom of the missile, the table can conveniently be used in conjunction with parts of a missile system, such as the autopilot or the control console of a firing range. If the missile is connected to an autopilot as well as to the computer, it can be used for pilot training. The pilot can fly a theoretical missile using the same controls as he would at a test base for a free flight.

A second major use of the table at Downey is for systems analysis and synthesis which involves closed-loop simulation. The flight table, with instruments mounted on it, is used primarily as a computing instrument, the goal being analysis of a complex dynamic system. In addition systems synthesis may be accomplished with mathematical simulation by using the analog computer.

The flight table and the instruments mounted on it represent a greatly increased capacity in terms of regular analog equipment. The use of the flight table in systems synthesis work, in addition to providing realism through the use of actual hardware components, thus greatly augments the over-all computing capacity of available flight simulation equipment.

The table at Downey has been used primarily for missile development, but it can be applied to manned aircraft as well. It might be used to simulate conditions experienced in boosted flight or under free fall and re-entry. It could also be used for checkout of flight control systems and to solve problems connected with the maneuvers of high-speed fighter and bomber aircraft.

Ironing out "bugs" in the hundreds of individual components and assemblies that go to make up a missile is no easy matter. The complexity of modern missiles has made the use of flight simulators of this type a must to keep development costs at reasonable levels.

Point of No Return

Britain's new naval fighter the Scimitar (Vickers Supermarine N. 113) is catapaulted from the bow of H.M.S. Ark Royal, Britain's largest aircraft carrier. The plane is powered by two Rolls-Royce turbo jets and has guided missile capability.

Fuels for the Future

(CONTINUED FROM PAGE 35)

of molecular hydrogen, impulse values of greater than 1000 sec are calculated. This is four times that presently realized. Atomic hydrogen has a heat content of about 50 kilocalories per gram, Dr. Moe explained, versus about 3 kcal/gm for conventional fuels. But many problems in harnassing this energy can be seen even now.

Among these difficulties are the phenomenally high temperatures that would be created if the fuel consisted exclusively of atomic hydrogen. Combustion chambers would evaporate within seconds. But, more important, the molecular hydrogen coming out of the exhaust would be broken apart into free radicals again, with the attendant loss of important amounts of energy. At 2300 C, significant amounts of redissociation would occur, and at 5000 C there would exist an equilibrium condition where 45 per cent of the existing gases would be free radicals.

Atomic hydrogen concentrations must be about 10 per cent to provide any important increase in thrust over present systems. To date, concentrations of less than 1 per cent have been the best obtainable in laboratories. And even these degraded very rapidly, even though frozen with the molecular hydrogen at liquid helium temperatures of about 4 K.

Dr. Moe believes that the working fluid for an atomic hydrogen radical system could be either molecular hydrogen or helium. Other radicals being looked into by Aerojet under a three-year-old Air Force contract are NH and CH, as well as atomic nitrogen. Generating the radicals for study at Aerojet is a 1000-curie Cobalt-60 gamma ray source, which irradiates material at liquid helium and liquid nitrogen temperatures.

Free radical propulsion systems at present still appear far off, and it is generally felt that at least one major

breakthrough will be necessary before such systems are realized. But, because present fuels severely limit space travel, another source of propulsion energy must be found. Many rocket men are betting time and dollars that free radicals will provide the push for the next step into space.

Missile Market

(CONTINUED FROM PAGE 52)

fully scrutinized to ascertain if commitments in these equities are suitable for a particular portfolio.

Reaction Motors

(Traded over the counter, approximate price: $27. Reported for 6 months ending June 30: Sales of $12.5 million vs. $6 million, net per share $0.75 vs. $0.41; 246,643 shares of common outstanding, 50 per cent owned by Olin Mathieson, 23 per cent by Laurance Rockefeller.)

Started in 1940 by several members of the American Rocket Society, Reaction Motors has become an important factor in the field of rocket propulsion. Primarily a developer of rocket power plants for guided missiles, supersonic aircraft and aircraft launching systems, the company is also engaged in chemical and physical research on rocket propellants, combustion, metallurgy and advanced rocket design concepts. The company's backlog in June of this year was $22 million and sales are increasing at a rapid pace. Part of the OMAR team (formed in 1955 by Olin Mathieson, Reaction Motors and Marquardt Aircraft), the company's management foresees plenty of growth ahead. The extremely small floating supply of stock available (probably not more than 40,000 shares) could make for some dramatic price performance, and the stock is down more than 35 per cent from its recent market high. No dividend paid or expected.

Ramo-Wooldridge

No direct investment is possible in this Company, but its outstanding success in the field makes investment in Thompson Products, whose principal business is the manufacture of aircraft component parts and auxiliary equipment, an attractive consideration. Thompson Products presently owns a 49 per cent interest in Ramo-Wooldridge, which could be increased to 84 per cent through exercise of stock options.

Thompson Products

(Traded New York Stock Exchange, approximate price: $57. Reported for 6 months ending June 30, 1957: Sales of $196 million vs. $143 million, net per share $2.96 vs. $1.72; 2,759,158 shares of common outstanding.)

Thompson's sales and earnings should reach new peaks this year at $400 million and $5.50 per share. While 1958 results may show some declines from these levels, increasing work in missiles and electronics and a sizable volume of automotive parts should partially offset the drop expected in jet engine components, largest source of sales in recent years. Ramo-Wooldridge sales and earnings for the first 6 months of this year were $21 million and $543,000 respectively. Earnings are still being substantially reduced by heavy research and developments charge-offs. R-W sales could, by 1960, reach the $100–200 million level, producing earnings of $0.75–1.50 per share of Thompson, based on present ownership. By then, Thompson earning power per share of common should be up at the $8–10 level, including the R-W contribution.

An increase in the $0.35 quarterly dividend is believed likely before the end of the year. A $4.00 preferred and a $4\frac{7}{8}$ per cent convertible debenture are also available for investment.

Market Letter Gleanings

General Precision Equipment–"Shares are down sharply from their highs . . . . and, with considerable near-term earnings improvement in prospect, we would fully retain existing commitments. The stock will probably continue to have tax-free dividends for several years."

(Standard & Poor's)

"We continue to recommend *Raytheon* as an improving situation. The company combines all the ingredients of glamour and growth necessary to have its shares sell at high multiples of earnings once the recently revitalized management has demonstrated Raytheon's true earning power."

(Oppenheimer & Co.)

Hercules Powder–"We believe this issue represents one of the more attractive quality chemical growth stocks today, and should be considered for inclusion in those accounts interested primarily in capital appreciation and where income is of secondary consideration." (Hayden, Stone)

"Aircraft issues, recently one of the weakest groups, seem to have discounted most adverse developments in the industry. *Douglas* and *Northrop* seem to be among the best-situated in case of a recovery."

(Joseph Faroll & Co.)

"The following stocks are typical of those 'research-conscious' companies which should eventually be in all long-term growth portfolios: *Bendix Aviation, Thompson Products, Thiokol, Litton Industries.*" (Forbes)

Aircraft Stocks–"Evidence is mounting that the over-all drop, climaxed by pessimism arising from the reshuffling of the nation's air defenses, may have gone too far." (Barron's)

Financial Briefs

Thiokol president sees 1957 earnings at $3.00 per share. . . . *Litton* earns $1.47 in fiscal year ended 7/31/57 vs. $0.97 previous year, with backlog at $49 million; acquires Maryland Electronic Mfg. Corp. for stock. . . . *Ryan* earns $2.88 per share in nine months ended July 31. Paid 20 per cent stock dividend October 30th. . . . *North American Aviation* chairman indicates fiscal 1957 sales and earnings at record $1.2 billion and $4.02 per share, predicts fiscal 1958 sales drop to $700 million. . . . *G. M. Giannini* earns $0.58 per share in 6 months ending June 30, predicts sales of $11 million for full year. . . . *The Martin Company* president anticipates sales of over $400 million for both 1957 and 1958, puts present backlog around $800 million.

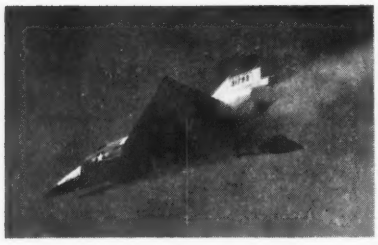
Lockheed midyear backlog at $1.4 billion. . . . *American Bosch* earns $1.56 vs. $1.16 in six months ended June 30, puts backlog at $225 million. . . . *Bendix Aviation*, for 9 months ended June 30, earns $3.97 vs. $3.21. . . . *General Precision Equipment's* earnings jump to $2.10 from $0.84 the previous year, for first six months. . . . *Sperry Rand* sells $110 million bond issue with stock warrants attached. . . . *General Tire* sells $12 million debenture issue with warrants. . . . *Olin Mathieson* to sell $60 million convertible debenture issue.

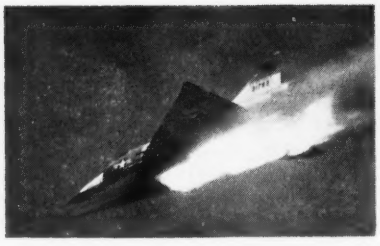
Northrop's New Divisions

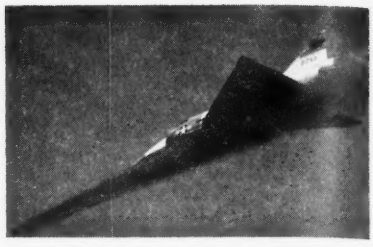
Nortronics, a new line operating division of Northrop, Inc., will handle the corporation's growing activities in electronics, electro-mechanical, and related opto-mechanical product areas. Complete details on Nortronics location and organization will be announced soon.

Radioplane Co. has been merged into Northrop Aircraft, Inc., as a line division, known as "Radioplane, a division of Northrop Aircraft, Inc."

Northrop had operated the Van Nuys firm as a wholly-owned subsidiary since 1952 when the company was acquired. Under the realignment, Radioplane maintains its own group of division officers and has separate profit-and-loss responsibilities.







Deadlier by the Dozen

It takes less than half a second for the Convair 102 to spit out its salvo of 24 folding-fin rockets. When all rockets have been fired (second photo), their exhaust blends into one massive sheet of flame making the 102 look like its underside is afire. F-F rockets are actually secondary armament to the interceptors Falcon guided missile.

First Space Man

(CONTINUED FROM PAGE 31)

the long trek, following the balloon westward from Minnesota to the Dakotas. Over Brainerd, the balloon reached a height of approximately 100,000 ft, from which Maj. Simons could see beyond Lake Michigan under a violet-dark blue sky rimmed at the horizon by a halo of white. Through the patches of broken sky below, the most outstanding landmarks were the rivers and lakes. The earth colors appeared faded in the view straight down from 19½ miles.

Throughout the afternoon, the flight differed very little from Capt. Kittinger's test flight, except for the continuous recording of observations and data in an attempt to sample various kinds of meteorological, physical, astronomical, geophysical and human psychophysiological material. Maj. Simons made photographs and used the 5 in. telescope mounted vertically along the side of the gondola.

Gondola Twisted

He reported one annoyance. Whenever he moved, the gondola slowly twisted and rotated, swinging back and forth against the elastic deformation of the balloon for a brief period. This made telescopic observations difficult, since even a sudden movement of the hand could start the gondola rotating.

The procedure that was followed on the ground was to drive for about an hour, getting some 40 or 50 miles ahead of the balloon, and to stop at the nearest airfield so that communications could be maintained with the fleet of one AF and two Army helicopters, two AF C-47's, and one chartered Navion flown by Mr. Winzen's chase crew.

At Detroit Lakes came an hour of decision. During the afternoon, the radio beacon became inoperable, so the high-frequency radio channel which transmitted heartbeat and respiration sounds could no longer be received at the radio van, and there was a possibility that even the VHF channel might be lost. In addition, a large thunderstorm area had formed under the balloon, so aircraft tracking appeared impossible during the night.

These events were reported to Maj. Simons, and the decision as to what to do was left up to him as project officer and subject. It was his considered opinion that the risks of remaining aloft through the seven hours of darkness would be worth the results that could be obtained from observation and experiments.

After sunset, the caravan moved to Fargo, S. Dak., where adequate airport facilities and weather forecasts would be available. Although 100 lb of batteries had been dropped as ballast shortly after sunset, an unforeseen complication arose. The storm clouds prevented earth heat from radiating to the balloon, and the cooling helium let the balloon descend gradually to 67,000 ft instead of keeping it at the predetermined 90,000 ft, anticipated for night conditions in the clear.

At this point, Maj. Simons was reporting intense lightning activity below and a rate of descent of 500 fpm from a possible downdraft, and noted that, at 67,000 ft indicated altitude, nearby wisps of clouds were blotting out stars from the view in the direction of the horizon.

After a conference between Mr. Winzen and Maj. Simons, it was decided to drop two more partly expended 50 lb batteries and arrest the unexpected descent. The balloon stabilized and slowly rose to 68,400 ft, where it remained until daylight. For Maj. Simons, daylight came at 4:45 a.m., one hour and 15 min before the sunrise was seen at ground level.

The gondola had gradually cooled during the night, in spite of the four-ply aluminized mylar and honeycomb paper insulation, reaching a minimum of 37 F cabin temperature at 4:30 a.m. At this point, Maj. Simons put on a special insulation suit and made a report on the sunrise which was as scientifically poetic as his description of the sunset. Presently, intense heat from the radiation of the sun caused the balloon to rise slowly, and by midmorning it was above 90,000 ft.

Found CO_2 Content High

Maj. Simons demonstrated retarded reactions in reading instruments over the VHF radio, and, when he was asked to do an analysis, found carbon dioxide content had risen to 4 per cent. He was immediately asked to close the face plate and alternately breathe on the oxygen system of the pressure suit for 10 min and then breathe capsule air for 10 min. This procedure permitted the chemicals to clear the atmosphere of the gondola to approximately 2 per cent carbon dioxide. Thereafter, Maj. Simons resorted to the mask whenever the cabin carbon dioxide content went over 3 per cent.

During this period, he was still over several layers of overcast and was making his own weather observations, in addition to plotting his position. From his height, he could see a clearing beginning to appear in the West. At the same time, ground weather stations reported this clearing to be over Aberdeen, S. Dak. Maj. Simons reported the clearing to be approximately 75 by 100 miles in extent. If he could hold out until movement of the balloon, drifting slowly westward at 100,000 ft, coupled with the southeastward drift of the clouds below him, got him in the clear, he could come down without passing through the thunderstorms in the cloud layers below.

One of the C-47's was dispatched to go beyond the clearing and look eastward for Maj. Simons above the clouds. In very short order, he was located about 18 miles north northeast of Aberdeen. At this point he

began valving off helium to initiate a descent rate. This took considerably longer than had been anticipated. At first he thought it was because of an updraft, but it was later determined to be a quirk in operation at this altitude.

To conserve electricity for the unpredictable period the balloon would remain in the air, it was necessary to leave the circulating fan of the evaporative cooling system off and give priority to the air recirculating system which removed moisture and carbon dioxide from the enclosed atmosphere. Dressed in the M3 partial pressure suit, Maj. Simons found that temperatures higher than 65 F became quite uncomfortable in the gondola.

After more than three hours of struggling, he finally reached 80,000 ft. Thereafter he gradually increased his descent rate until it approached 1000 fpm by the time he reached the tropopause at about 45,000 ft. A few thousand feet above the ground he jettisoned the remaining two 50 lb batteries and established a final descent rate of 600 to 800 fpm, finally coming down in a flax field six miles from the North and South Dakota borders and about 10 miles from the town of Frederick, S. Dak. He released the balloon, jettisoned the upper hatch of the gondola, which was lying on its side, and crawled out.

Aside from losing several pounds due to prolonged exertion and dehydration in the pressure suit, he was in good shape. The helmet was removed and the upper part of the pressure suit opened, and he climbed into the helicopter for the trip back to Fargo, S. Dak. He was talking about the trip when suddenly, in the middle of a sentence, he fell asleep. Upon arrival in Fargo, he cleaned up, changed clothes, and was moved by C-47 to Minneapolis.

The amount of activity and the extraordinary effort Maj. Simons put out, to collect and record data with one hand while keeping himself alive with the other, resulted in about 25 hours of intermittent tape recordings of radio transmissions and $5^1/_2$ hours of dictaphone records. He also took many rolls of still and motion pictures with several cameras. It will be some time before all the data are reduced, and recordings transcribed and correlated with the photographs.

The Meaning of "Sputnik"

(CONTINUED FROM PAGE 25)

chemistry and metallurgy.

He went on to note that for many years Russia has had in a number of fields first-class scientists and facilities, often on a par with, and sometimes superior to, any in the world, including the U. S. In addition, the country has a long history of outstanding scientific achievement.

To build its present highly competent, excellently trained and numerically large force of scientists, Russia has provided educational and other conditions encouraging the maximum development of the large scientific potential that existed in the country.

Research Followed Carefully

Another important point is the careful attention Russia gives to research work performed outside the country, attested to by the fact that the Soviet Union has a very large and elaborate organization for collecting, publishing and distributing to its own scientists technical information from all parts of the world as quickly as possible.

This, however, Schwartz noted, would hardly suffice to explain how Russia appears to have outdistanced us, for the moment, at least, in rocket technology and space flight. The full answer, he suggested, lies rather in a comparison of the environments in which Russian and American scientists have worked while seeking answers to problems in these fields.

In a totalitarian state, all its resources—natural, scientific, military and economic—can be and are concentrated on the accomplishment of objectives of primary importance. Since the accomplishment of space flight is obviously one such objective, it can be assumed that all the huge human and material resources of the Soviet Union have been made available without stinting for the project.

In the U. S., on the other hand, the Vanguard project has been allocated relatively modest resources, on a scale inadequate to do the job Soviet scientists have done in a relatively short time. Here, Schwartz concludes, the prestige resulting from being first with a satellite was regarded as having a relatively low priority by those who allocate government funds, with results which have now become known.

Another question which bothered a lot of people is why no inkling that the Russians were so close to a launching had leaked out. It was obvious at the Washington IGY conference, which began five days before the launching, that even top-ranking American scientists working on Project Vanguard had no idea that a Soviet satellite firing was imminent.

As a matter of fact, the first information released by the Russian delegation to the conference on the satellite, which indicated radio transmission at frequencies of 20 and 40 mc, rather than on the 108 mc band publicly announced for our satellite, created consternation among American scien-

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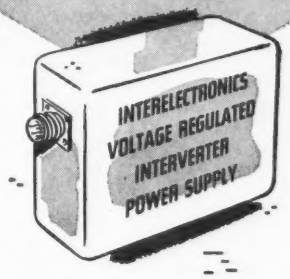

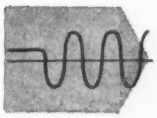

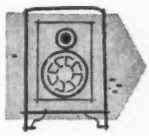

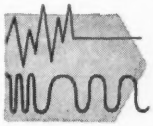

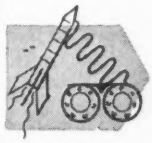

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Soviet Outpost **Part of Russia's IGY facilities, these particular buildings belong to a Soviet scientific "district" set up to study the ionosphere and propagation of radio waves.**

tists at the parley. And the Russian papers on sounding rockets and their instrumentation created a flurry of notetaking among American rocket and satellite experts, indicating that this was the first time they had received any information on these subjects.

The conclusions are obvious: Either our intelligence services have failed in their attempts to keep abreast of Soviet rocket, satellite and guided missile activities, or this information, if it has been obtained, is not being made available to the men who need it most—American scientists working in these fields.

Although speculation on these questions continues both in and out of Washington, it has dropped to a quiet buzzing. The big question at the moment, of course, is: What happens now?

Russia has already announced plans for the imminent launching of a larger and more sophisticated satellite, as well as one that can be recovered. A Pravda story also said plans were being made to launch a satellite carrying animals. American scientists, meanwhile, are trying to get as much information from Sputnik as possible and, at the same time, are moving ahead with plans for Project Vanguard.

Just what effect Russia's successful satellite launching will have on these plans remains to be seen. It is known, however, that the Vanguard staff has been contemplating some changes in proposed plans for the U. S. satellite program.

The one thing that does appear certain is that most missile and satellite men are paying little heed to the government's belt-tightening gestures. They feel this is only a superficial contraction of the face-saving muscles, and look forward to increased spending on the satellite program, as well as a subsequent loosening of government purse strings for missile programs in general, as a result of Sputnik.

Press reaction to the Russian feat was pretty much in line with this thinking. The reaction from newspapers around the country was more or less summed up in editorials in the *New York Times* and *Herald Tribune*.

The *Times*, in an editorial on Sunday, Oct. 6, carrying the headline, "Stride into Space," hailed the accomplishment as "one of man's finest achievements . . . a feat of which mankind may be proud."

However, the *Tribune's* leading editorial the same day, headed "A Grave Defeat for America," passed up the congratulations to examine the implications of the feat. It noted that unlocking the atom—accomplished by throwing unlimited American funds and our best scientific brains at the problem—gave the U. S. world supremacy in scientific research and development, but that the Red satellite means we have lost that supremacy.

Examining why this has occurred, the editorial agreed with Harry Schwartz that the reasons were quite clear. "The Soviet Union allows nothing whatever to interfere with the top priority of its scientific research . . . while the free world, ironically, has been harassing and hamstringing its own scientists." As a result, "the Soviets have not only passed us in satellites. They have passed us in the very realm of missiles."

Suggested New Manhattan Project

"In the face of all this danger," the editorial went on, "is the government now launching a belated, all-out effort, comparable to the Manhattan Project, to overtake the Soviet lead? No. On the contrary, the Defense Dept. at this very moment is launched on a retrenchment of the missile program. . ."

"This is madness," the editorial concludes. "What this nation needs is not the deprecation of scientists, but one of our greatest scientists in the Cabinet. What this nation needs is not the starving of research and development . . . (but) a national program . . . on a scale of grandeur and imagination to equal the Manhattan Project."

The following day, the *Times*, perhaps having some second thoughts on the matter, echoed the sentiments expressed in the *Tribune*. The Soviet satellite, it noted, "raises questions of the gravest character regarding the correctness of our present and past national policies."

Then it posed a number of these questions. "Why did not our policy makers realize the tremendous prestige, propaganda and political gains likely to accrue to the Soviet Union if it was the first to send up a space satellite, and why were not adequate steps taken to assure that that eventuality would not arise?"

"Are we making a maximum effort at the present time . . . to insure that we too have intercontinental ballistic missiles at the earliest possible time? If not, should we not increase our effort so that it is the maximum possible one, utilizing all the rich resources of our science, technology and industry?"

The answers to these questions may be found in what promises to be a painstaking reappraisal of our present military and fiscal policies. If current signposts are any indication, this nation may take a page out of the Soviet Union's book and ready an all-out assault on outer space in the very near future.

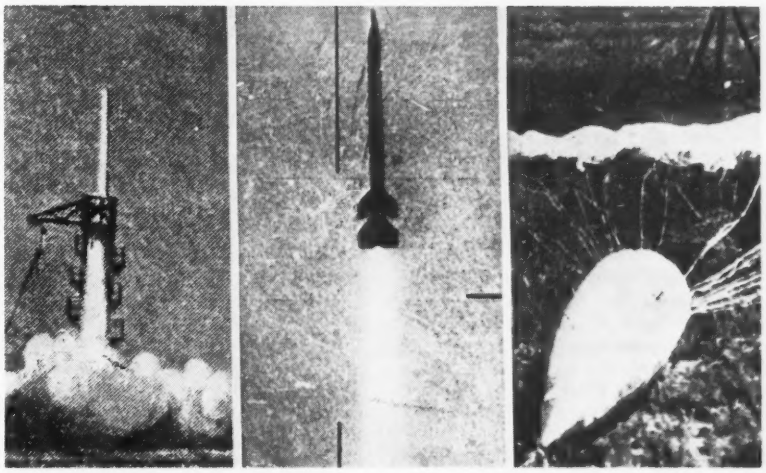
Russians Talk about Rockets at IGY Conference

WASHINGTON, D. C.—Details of Soviet research rockets and rocket experiments were revealed for the first time last month at an international conference at the National Academy of Sciences here to coordinate IGY rocket and satellite activities. Scientists from the other 12 nations participating in the conference commented that this was the first time the Russians had revealed any information about its rockets at a meeting of this kind.

However, the Soviet delegation canceled a scheduled report on its satellite launching vehicle and launching program and turned aside all questions as to when and where satellite launchings would be attempted.

Some additional details concerning planned Soviet satellite experiments were contained in two Russian papers dealing with this subject. In all, the Russians presented a total of five papers, and provided the conference with additional material relating to the papers which has already appeared in Soviet technical publications.

The Soviet delegation was made up of A. A. Blagonravov, a member of the Presidium of the Soviet Academy of Sciences; Sergei M. Poloskov, a professor at the Geophysics Institute of the Academy; and A. M. Kasatskin. Dr. Blagonravov, one of the U.S.S.R.'s top scientists, has administrative charge of many IGY satellite research programs, but neither he nor either of his companions is actually working on the launching vehicle itself.



Russian meteorological rocket. Photo at left shows launching, with in-flight shot center and, at right, view of nose section containing instruments which detaches at altitude of 50 miles and is parachuted back to earth.

Rocket Described

Of particular interest were the papers by Dr. Kasatskin on the Russian "meteorological rocket," and by Dr. Poloskov on Russian rocket experiments from 1951 to 1956 to determine composition of the earth's atmosphere at high altitudes.

The rocket described by Dr. Kasatskin was developed in 1950, has been successfully tested a number of times and is to be used for IGY experiments along with another research rocket, referred to as the "geophysical rocket" but not described.

Instrumentation is said to be simple but reliable, and firing techniques good. One advantage claimed is easy launching, since elaborate equipment is unnecessary and the launching tower is easily transportable permitting firings from almost any location.

The rocket consists of three parts—an instrument section topped by a needle-like nose, the rocket body itself, and a booster. Launching weight is about 1 ton, making it heavier than any American research rocket. Length, not including the needle nose, is about 29 ft.

Among its unusual features are a hollow solid propellant booster, through which the liquid sustainer motor fires, and the inclusion of two parachutes which facilitate recovery of both the instrument section and the main rocket body.

The rocket is fired from a unique spiral launching tower which provides spin stabilization on launching. The main power plant is a liquid rocket engine, using aviation kerosene and nitric acid. Fuel feeds by air pressure and is chemically ignited. Engine thrust is about 3000 lb, duration 60 sec. Booster and sustainer engines are fired at the same time; and, by the time the booster burns out (2 sec), the sustainer engine has attained full thrust. This cuts the height of the launching tower used to about 40 ft.

Spin imparted to the rocket on launching is slowed down by the fins on the main body of the rocket, as well as on the booster, after speed is attained. At booster burnout, velocity is 170 m/sec; at burnout of the sustainer, slightly above 1100 m/sec.

At an altitude of about 45 miles, the main body and the instrument section are separated by small solid propellant rockets. Each continues to rise, trailing its parachute behind it, until the instrument section achieves a maximum height of about 55 miles.

From peak altitude down to about 40 miles, drag from the trailing parachute is negligible. At this point, the parachute opens and the instrument section floats back to earth, landing at a velocity of 4–5 m/sec. Meanwhile, the main rocket body has also been parachuted back to earth.

The parachutes are rectangular, and about 700 sq ft in area. Use of the parachutes permits recovery and reuse of both the instrument section and the main rocket body. Dr. Kasatskin indicated that some instances the instrument section actually came down a short distance from the launch point.

American scientists at the meeting were intrigued by some aspects of the Soviet vehicle, especially the hollow booster. The general feeling was that the rocket tends to be mechanical, rather than electronic, at a cost in additional weight. It is also somewhat simpler than American research rockets, although some of the design concepts are quite advanced.

Soviet Technique Differs

Dr. Poloskov's paper dealt with successful Soviet attempts to obtain air samples at altitudes up to about 100 km. The Soviet technique was somewhat different from methods used in similar attempts in this country in that the vacuum bottles used were thrown clear of the rocket, thus allowing uncontaminated samples to be collected.

Results of the tests differed somewhat from similar American experiments, although failure of the Russians to indicate the exact point at

which the rockets were fired, other than "the central part of the European area of the U.S.S.R." negated exact comparisons. In general, results of the Soviet experiments seemed to indicate lower pressures and temperatures than American experiments at heights above 80 km.

In other Russian papers, Dr. Blagonravov gave the results of Soviet experiments designed to estimate satellite life and also indicated that the Russians would attempt to fire smaller satellites first. In general, Russian calculations on satellite life appear to be somewhat more optimistic than our own.

Covered Experiments

Dr. Poloskov, in two other papers, covered Russian ground-based and satellite-borne experiments, but failed to release any significant new information, except that an attempt will be made to photograph the sun's corona. No details were given as to how this would be done.

Scientists at the meeting, however, foresaw the fact that the Russian satellites would be considerably heavier than ours. One reason for this belief was that the power supply mentioned for the Russian moons was of the order of 1 watt for a period of about 3 weeks, while the power supply in American satellites is measured in milliwatts.

Dr. Poloskov also indicated that the Soviet satellites would broadcast alternately on frequencies of 20 and 40 mc. He explained that the 20 mc signal was selected to facilitate studies of the effects of ionization on radio wave propagation, while the 40 mc signal was being used to permit tracking of the satellite by amateur radiomen in Russia. There was no indication in his paper that the Russians had established a chain of tracking stations in the Soviet Union similar to the U. S. Minitrack system.

The Russian delegation then urged that the American precision optical tracking system devised for our satellite be used to track the Soviet satellite as well.

Scientists at the meeting also heard complete reports on American, British, Australian, Japanese and Canadian IGY rocket activities. H. S. W. Massey of the British delegation reported that its Skylark had achieved an altitude of 150 km in three tests at the Woomera range in Australia, while Takeo Hatanaka noted that the Japanese program was well along the way toward firings of a number of Kappas and Rockoons, the latter utilizing new Sigma and Pi rockets.

Work is being pushed on an IGY manual relating to rockets and satellites, which would be Volume VI in the IGY series. As a result of editing progress at the meeting, publication is expected about the end of this year.

In opening the conference, L. V. Berkner, reporter for IGY rocket and satellite programs, expressed the hope that international cooperation in these areas would continue beyond the end of IGY.

This hope was realized with the announcement at the final plenary session that Soviet and U. S. scientists had agreed to extend coordination of rocket and satellite firings beyond the IGY period.

In addition, scientists from the East and West agreed to hold a world-wide rocket shoot next June 18, the objective being to fire as many rockets as possible on that date so as to obtain a composite picture of the upper atmosphere.

The conferees also provided for a broad exchange of data concerning upper atmosphere research, with reports on rocket firings to be circulated within two weeks after each shot.

I.H.

Satellite Launching Problems

(CONTINUED FROM PAGE 21)

precise, the velocity V_e is measured with respect to a hypothetical non-rotating earth; the velocity relative to an observer on the surface of the actual rotating earth is slightly different and would depend on the latitude and the course direction.

The required launching energy per unit mass is then calculated by adding the kinetic energy of the satellite in its orbit and the potential energy connected with the altitude h. It is convenient to express this launching energy in terms of an "effective launching velocity" (V_L) since the performance of a rocket launching system is usually described by reference to the "burnout velocity." The effective launching velocity of a rocket is always a few per cent larger than the actual burnout velocity because the former includes a kinetic energy increment equivalent to the potential energy at the burnout altitude.

Comparison of the energy required for complete escape from the gravitational field of the earth, E_∞, with that required for a low-altitude satellite, E_0, shows that the ratio is 2. That is, a 41 per cent greater launching velocity is required for an escape project or a Moon rocket.

In the illustration on page 20, we can see how the choice of orbit altitude affects the required effective launching velocity, and we show also the orbital velocity (referred to an inertial space) and the period of revolution. Several significant points emerge from an examination of these results. The first is that the period is about 90 min for a low-altitude satellite and becomes longer as the altitude increases. A satellite at 1000 miles altitude would revolve once every two hours.

An interesting result is that a satellite 22,000 miles from the center would revolve once per day, so that if it were injected eastward into an equatorial orbit it would remain in the sky in a fixed position, potentially visible at all times by all observers in one hemisphere. Finally, for the purpose of checking the analysis, it can be calculated that a satellite at the distance of the moon, 238,000 miles, would revolve once every 28 days.

Examination of the curve for V_L shows that, to place a satellite at 400 miles, requires an effective launching velocity of 27,100 ft/sec. The orbital velocity will be 24,800 ft/sec or 16,900 mph. The burnout velocity of the launching rocket would be about 26,000 ft/sec, if the most economical path of ascent were utilized. (Atmospheric drag is almost negligible in the launching of a large rocket.)

To appreciate in proper perspective the nature of the engineering achievement represented by the successful launching of a satellite, it is instructive to compare the necessary effective launching velocity of the satellite with those of other projects. In the illustration on page 20, six projects of current interest are portrayed. The first is the V-2, considered as representing the most advanced state of the art in the immediate years after World War II. The effective launching velocity of the V-2 is about 5000 ft/sec, the range about 200 miles.

Launch Velocities Compared

A decade later, in 1957, long-range intercontinental missiles are reported to have been successfully developed, perhaps even to the extent of having production lines, trained crews and operational capability. Two such missile trajectories are illustrated, an ICBM-1 with a range of 3000 miles, and an ICBM-2 with a range of 7000 miles. Although these trajectories are drawn like parabolas over a flat earth, the calculations were actually made for elliptic paths over a circular earth. The U.S.S.R. has announced a 5000-mile range missile. By means of this graph, we can estimate this rocket assembly to have an effective launching velocity of about 22,000 ft/sec.

Next we consider two earth satellite vehicles, ESV-1 and ESV-2, each

intended to place a satellite in a 400-mile orbit. It has already been shown that, with the most economical ascent, an effective launching velocity of 27,100 ft/sec is required. For reasons to be discussed below, it is impractical to follow the ESV-1 path of ascent. Instead, the ESV-2 path is proposed (and was reportedly used by the Russians), but it can be shown that this requires somewhat larger rocket burnout velocities and is equivalent to a rocket system capable of an effective launching velocity of 29,500 ft/sec. (All these figures ignore the slingshot contribution due to the earth's spin; the magnitude of this contribution could be positive or negative, depending on the firing direction.)

It is clear that a 5000-mile range ICBM can be used to launch a satellite if a way can be found to augment the effective launching velocity by about 7500 ft/sec. This is easily possible, as will be shown in later calculations.

An earth-escape vehicle requires a launching velocity of 36,700 ft/sec. There has been some speculation that ICBM launching equipment could be used to send a small research vehicle to the moon, since the necessary increment in velocity (14,700 ft/sec) could be provided by one or two extra stages in place of the warhead. This will be confirmed by calculations below.

Finally, we might consider the recently announced Project Far Side, which has as its objective the sending of a small research vehicle upward to a peak altitude of about 4000 miles. This is a radial distance of 8000 miles, at which point the potential energy is exactly one-half that required to reach the moon and just equal to the total energy of a low-altitude satellite. (The Far Side launching is to take place from a balloon at about 80,000 ft to eliminate the drag, which would otherwise be quite significant.) It is clear, therefore, that the Russian satellite launcher could also project a payload to a 4000-mile altitude, if directed straight up, and vice versa, that the Far Side launcher could create a satellite if it were equipped with a guidance system.

Choice of Orbit Altitude

Several considerations dictate the choice of orbit altitude, namely, lifetime of the satellite, communication with stations on the surface of the earth, possible errors in launching velocity and direction, and the required launching energy.

The last consideration can be examined with the help of the previous graph. For low altitude satellites (below 1000 miles) the effective launching velocity V_L has to be increased by about 250 ft/sec for each gain of 100 miles altitude. If the design factors are marginal (as, for example, in the case of Vanguard) the choice of a 300-mile altitude instead of 500 miles represents an important saving.

It is obvious that a satellite at too low an altitude will fail to stay up as a result of relatively strong drag forces. It is useful to examine the physical factors on which the lifetime depends. The problem can be discussed most clearly in terms of the loss in altitude Δh per revolution of a nearly constant-altitude orbit. A simple analysis can be made for the case of weak drag forces, a case that is really of greatest interest since strong drag would make the satellite nearly useless. The result is: $\Delta h \cong 2\pi R^2 \cdot C_D \rho_a / (M_s/A_s)$.

In this equation, R is the radius of the earth, C_D is the drag coefficient of the satellite in free molecule flow at about Mach 25, ρ_a is the density of the atmosphere at the orbit altitude, and (M_s/A_s) is the mass per unit frontal area of the satellite. The significant parameters are ρ_a and (M_s/A_s).

Probable values of atmospheric density are: At 140 miles, 1.0×10^{-13} slugs/cu ft; at 200 miles, 1.0×10^{-14}; at 290 miles, 1.0×10^{-15}; and at 450 miles, 1.0×10^{-16}. For a particular satellite, each successive altitude mentioned represents a tenfold decrease in the rate of altitude decay.

Frontal Area Density Vital

The frontal area density of the vehicle (M_s/A_s) is of great importance. The Vanguard satellite has a value of 10 lb/sq ft; Sputnik 64. For the same initial orbit, the Sputnik sphere will have 6.4 times the life of Vanguard. In order for Vanguard to have the same life, it will have to be set in an orbit about 100 miles higher than that of Sputnik.

It must be observed that the present uncertainty in the absolute values of the air density at these altitudes is about a factor of 10 larger or smaller. Using the quoted densities, and a value of 2.0 for C_D, it is calculated that a sphere of 10 lb/sq ft will last about eight days if started in a 200-mile orbit, and about eight months if started in 300-mile orbit.

Accordingly, Sputnik will probably remain aloft about four years, if its perigee is indeed at about 300 miles, as present reports indicate, and it may remain aloft as much as 100 years, if the density is taken at the lowest estimate and if the apogee is as high as 500 miles.

Space limitations in this brief article compel us to omit the discussion of lifetimes of elliptic orbits, but a very conservative lower bound is obtainable by treating an elliptic orbit as a circle at an altitude equal to the perigee altitude.

Line-of-Sight Observations

Another important consideration in the selection of orbit altitude is that scientific information is best obtained by line-of-sight observations, either optically or by high frequency radio. The greater the altitude, the more favorable are the conditions for acquisition of information, although at very great distances signal power and optical visibility may become a problem.

Consider the diagram on page 20 that shows a satellite at altitude h above the earth of radius R. The region on the earth's surface that can receive line-of-sight information from the satellite is a spherical cap, area A. A sighting or receiving station will have a range s. It can be shown by simple geometry that: $s^2 \cong 2Rh$, and $A = 2\pi Rh(R/R+h)$.

Thus, the number of sighting stations required to cover a specified region of the world can be greatly reduced by increasing the altitude of the orbit. For a 200-mile altitude, the range is about 1200 miles.

The time of passage from horizon to horizon, if the path lies directly overhead, is approximately $2s/V_r$. For a circular orbit at 200 miles, the time of passage overhead is about 9 min; at 400 miles, about 13 min. If the path crosses only an edge of the visible sky, the time will be shortened substantially. The rapid angular sweep of the line of sight and the brief time available for adjustment of the tracking devices complicate the communications problem.

The available time for observation is very much less than even the preceding calculations indicate if a telescopic camera is used that depends on illumination of the satellite by sunlight. The illustration on page 21 explains the reason. To see the sphere, the sun must be below the horizon to eliminate the bright blue background of the sky, caused by diffuse scattering of the sun's rays by the dense part of the atmosphere. That is, the sphere is visible just before sunrise or just after sunset. However, at such times, a large part of the orbital arc that lies between the horizons is in darkness because of the shadow cast by the earth. As a result, even though the time of passage from horizon to horizon may be about 10 min, the longest possible time for optical observation is about 3 min.

In the sketch, the observer O on the earth's surface EE' is sighting at the satellite vehicle S following the

course CC'. The effective top of the atmosphere is at AA'. The limiting points of good visibility are V and V'. From H to V, the sky is too bright to allow the sphere to be distinguished; from V' to H', the sphere is in darkness. The most favorable condition occurs when the visible stretch VV' lies near the horizon.

The Guidance Problem

If the launching rockets could be guided perfectly to enter the desired orbit with exactly the required velocity of injection in exactly the required direction, the satellite would follow the prescribed course without error. However, this cannot be expected. Rather, allowance must be made for possible errors in altitude, elevation angle, azimuth angle, and velocity at the moment of injection (end of propulsion or steering power).

One way to discuss the problem is to assume that errors can occur in elevation angle and in injection velocity, and to inquire as to the necessary extra altitude at the injection point to overcome the effects of these errors. Let us consider first the effect of error in velocity.

If the satellite enters the orbit at the proper altitude and in the proper direction, but with a slightly smaller velocity than that needed to maintain a circular orbit, it will gradually sink below the desired circle as it starts off around the earth and will follow an elliptic path. The apogee will be at the point of injection, the perigee will be on the opposite side of the earth, and the ellipse will be internally tangent to the intended circle. This is shown on page 21. It can be shown, for a low-altitude satellite, that the perigee will sink 100 miles for a decrease of 0.6 per cent in injection velocity, that is, about 150 ft/sec.

If the total impulse of the propulsion system cannot be guaranteed under field conditions any closer than 3 per cent, then the rocket should be designed to deliver 750 ft/sec greater burnout velocity than for the circular orbit, and the design orbit should be an ellipse with an apogee 500 miles higher than injection point.

This is the kind of program that has been announced for Vanguard. If this allowance for error is not made, there is a good chance the satellite will penetrate the atmosphere and be destroyed before it gets even once around.

Alternatively, the margin of safety can be placed in extra altitude of injection. Thus, the 750 ft/sec margin in launching velocity can be utilized to permit injection into a circle at a 300-mile higher altitude than the design circle. If the velocity falls short, the result is an ellipse. This type of injection at apogee seems to have taken place in the launching of Sputnik.

A similar analysis can be made for the case of injection at the proper altitude, with the proper velocity, but with an error in elevation angle. It can be shown that if injection takes place either upward or downward, the resulting path will be an ellipse instead of a circle, and that an elevation angle of plus or minus 1.4 deg will place the perigee 100 miles below the intended circle, as shown on page 21. If the guidance and autopilot system cannot be guaranteed any closer than 1 deg under field conditions, the injection altitude should be raised 70 miles and the corresponding injection velocity can in fact be reduced, but the effective launching velocity must be raised by 200 ft/sec. Control of azimuth angle is not as important from the standpoint of dangerous penetration of the dense layers of the atmosphere, so we will not discuss it here.

It is clear that, to allow for reasonable errors in propulsion system impulse and injection angle guidance, the effective launching velocity should be designed to be larger than the required minimum by at least 500 to 1000 ft/sec. Furthermore, the programmed orbit should be an ellipse with a perigee near the injection point and an apogee about 500 miles higher.

* * * *

Next month, in the second and concluding part of this discussion of satellite launching problems, the author will deal with multistage rockets, optimum path of ascent, choice of firing program and the design specifications for a satellite launching rocket system.

Vanguard Winners

The following individuals were recently announced as winners in the Vanguard Satellite Essay contest sponsored by The Martin Company.

First prize ($5000)—Theodore Lang, Pasadena, Calif. "An Equilibrium Trajectory for a Satellite Powered by Solar Pressure."

Second prize ($2500)—Robert L. Howell, Cambridge, Mass. "A Satellite Beacon Station."

Third prize ($1000)—Eugene Mechtly, Northampton, Pa. "A Technique for Increasing a Satellite's Energy Weight Ratio."

Honorable Mention ($500)—David J. Beaubien, Eugene Covert, Rolin J. Gebelein, Erwin A. Ullrich Jr., Robert J. Stoffel, Rudolf G. Kittlitz Jr. and Charles A. Barth.

Jet Engine Rights For Curtiss-Wright

Orenda's new Iroquois jet engine will be further developed, produced and sold in the U. S. by Curtiss-Wright under a 7-year agreement with Orenda Engines, Ltd., of Canada. The two companies will collaborate in developing further variants of the engine for very high speed high altitude military aircraft, and for commercial airliners.

Heinrich, Haley to Give Lectures on Space Law

Welf Heinrich and Andrew G. Haley will give a nationwide series of lectures this month on the topic: "The Law of the Age of Space." The tour will cover 18 cities in 13 states and the District of Columbia, beginning in Princeton, N. J., Nov. 4, proceeding across the country to the West Coast and back, and concluding in Washington, Nov. 26.

Dr. Heinrich and Mr. Haley will address the faculties and students of a number of law schools, in addition to apearing before meetings of several American Rocket Society Sections.

Dr. Heinrich, Prince of Hanover, is the author of the first doctoral dissertation on space law, entitled "Air Law and Space." Since completing his doctoral work, he has been active in Europe in the fields of space law and space flight. The lectures this month will mark his first public appearances in this country.

Mr. Haley was president of ARS in 1954 and is now a director and general consul of the Society. A practicing lawyer, he is the new president of the International Astronautical Federation.

The lectures will be open to the public and there will be no admission fee.

Tunnels Take Shape

Wind tunnel facilities for testing aerodynamic shapes of missiles and rockets in addition to manned aircraft are taking shape at Republic Aviation Corp. Scheduled to be in operation by mid-April, and costing $1,200,000, two tunnels will be built simultaneously and housed in a new 6000-sq-ft building at the main plant at Farmingdale. One will deal with aerodynamic problems in the transonic area, at the point where flying shapes break the sound barrier. A larger one will be used in tests up to Mach 4, or approximately 3000 mph.

Combustion Glossary—or Propellants Are Not All That Burn

blow out, blow up. Explosive deflagration following buildup of detonation factors, such as money cutoff; your best design man taking another job for a piddling $5000 a year more (you had toyed with the idea of taking the job yourself); a strike at the shop holding up the parts of your (you hope) prototype model. Then the chief of projects coyly wants to know when you're going to give him a progress report that shows a little progress.

burning rate. Rate at which a rocket design engineer oxidizes as his pet project fizzles on the test stand.

combustion chamber. Chief design engineer's office after a super-duper three-year project has daintily fizzed, chuffed, and prettily fizzled out before a visiting team composed of Secretaries of the Army, Navy and Air Force.

detonation. Announcement by the government agency from which you had expected at least a million dollars's worth of research and development work: "No work on that project this fiscal year."

discharge coefficient. Ratio of energy expended in talking about a project to amount of work actually done on the project. Usual value approaches infinity.

end of burning pip. As Gen. Snarky views rocket test, the rocket does a boomerang and heads right for the general's head. The burning-out he gives the vice-president in charge of rocket development is a pip.

exhaust(ed) velocity. Celerity with which you run for home after a day subjected to the usual combustion forces—incompetence, hypocrisy, idea stealing and halitosis.

flame zone. Those luminescent areas in the boss' eyes just before he lights into you on Monday morning with a tirade he's been dreaming up all weekend.

hang fire. Project engineer insisted your idea wouldn't work; you insisted it would. It hasn't worked, and he's just hanging fire to let you have it when the final test blows sky high.

heat transfer rate. The speed with which word gets around that you'd better get the lead out of a project.

hypergolic. What happens when you lock a liquid propellant and a solid propellant man in the same conference room.

igniter. Pay raise, which puts the fire under everybody.

ignition delay. Waiting for the fireworks when you have been called in for a session with the vice-president in charge of boosting production.

internal burning. Sensation in a difficult-to-define region of the viscera when a project going like a house afire is cut off by the research chief when he returns from a trip to France where his wife has discovered a chic rocket that "we've got to make one like right away."

mesa burning. Rocket engineering pressure curve. Shows the buildup of pressure the first hour, the attempt to maintain the pressure all day, and the falling back to atmospheric pressure an hour after he's off the job.

plateau burning. Nonturbulent, steady-state burning before full thrust (eating out everybody within range) develops, or before detonation (blowing your stack at your lab mechanic, and letting it go at that).

pressure-temperature ratio. The pressure you can stand before your blood begins to boil.

pyrotechnic. Characterizing the office secretary—to hear your wife tell it.

propellant. Usually characterized by excerpt of statement from research director to project engineer: "I'll give you $10 and three months, and you'd better come up with something that at least gets off the ground." Sometimes the research director simply says: "I understand Superjet is looking for rocket engineers." (Also known as "side venting," or "nonpropulsive detachment.")

regenerative cooling. Cold air blasted over a hot project by the competition.

regressive burning. You've had it. You're going to quit right now. But, well, there's the wife and the kids, and maybe the next project will work out better, and besides there's the patio to be put in next Saturday.

steady-state burning. What your wife does as you put in 70 hours a week trying to get fire under a smoldering project.

strand burning. The burning that runs from your heart down to your liver as the third of your three prototypes chuffs like a locomotive on the launcher.

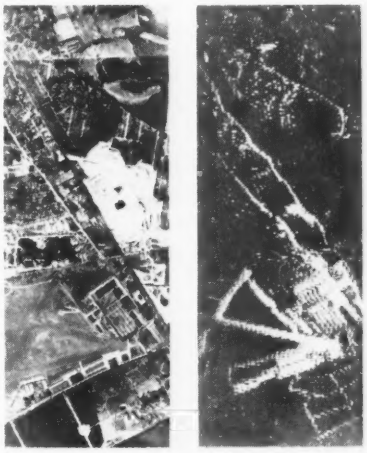
super-rate burning. Reaction when the report unit publishes your final report so edited, rewritten, and manhandled that it is scarcely recognizable as the manuscript you turned in and haven't seen nor heard of since. And, if anybody reads it carefully, he will come up with a conclusion exactly opposite to what you wrote in the manuscript you submitted.

surface velocity. Rate at which the project is moving according to the weekly progress report. It has nothing (at least not much) to do with what really is being accomplished (if anything).

turbulent burning. During a "brainstorming" session, a high-powered consultant at who-knows-how-much-a-day comes up with a notion that is precisely the idea you tried to sell three years ago and which got you hooted out of the project engineer's office. Now everybody choruses what a great idea it is.

—John H. Wilson
Atlantic Research Corp.

Heat Pictures



Mapping accuracy of infrared is shown in this recently declassified Air Force photo (left) which was recorded by an early passive infrared reconnaissance system designed and manufactured by Servo Corp. of America. Conventional photo is at right. The system makes use of the heat energy emitted by all objects with a temperature above absolute zero.

Army Exhibit

Year's biggest display of new Army weapons and equipment was set up at the annual meeting of the Association of the U. S. Army, Oct. 28–30, in Washington. Exhibit was on 25 acres at nearby Fort Meyer.

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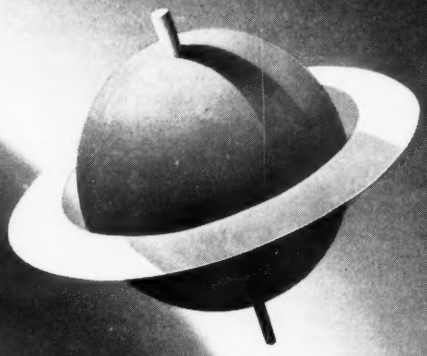

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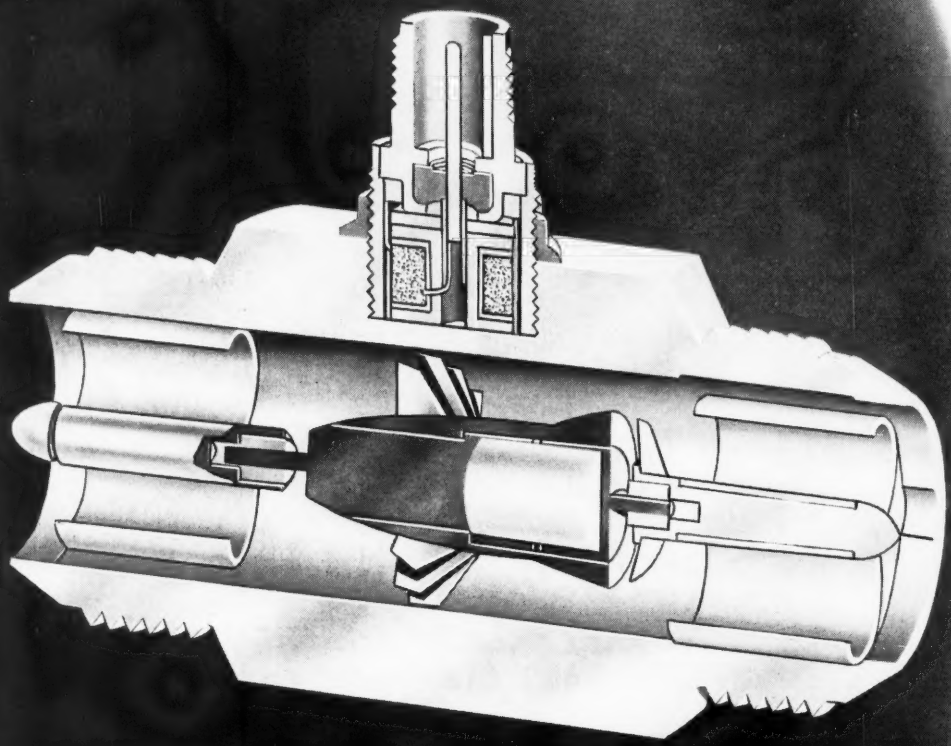

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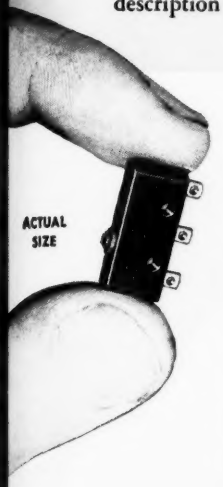

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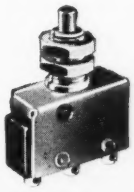
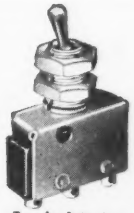
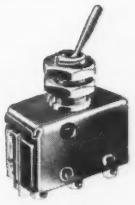
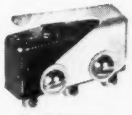

Push Button Actuator

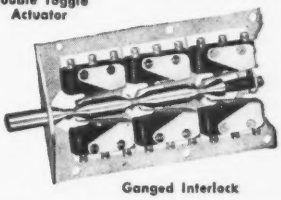

Toggle Actuator (Momentary or Constant Contact)


Double Toggle Actuator

Roller Leaf Actuator


Leaf Actuator

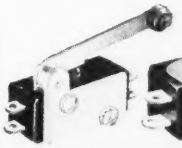
Extension Leaf Actuator

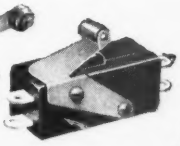

Ganged Interlock

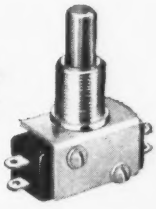
TYPE S SWITCHES Series S1

S.P.D.T., 2 circuit; 10 amps, 125/250 v. AC/ 30 v. DC. Ind. Screw or solder terminals on ends or one side of switch. Also available with reset button at bottom of switch or in Type S-100 Make-Before-Break Series where switch completes a new circuit before interrupting old one.

Write for Data Sheet STU-11

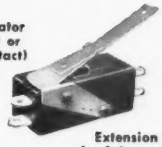

Roller Lever Actuator

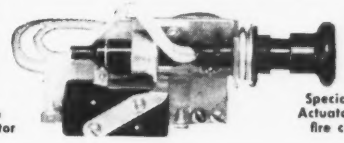

Roller Actuator

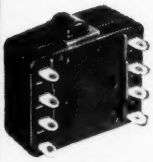


Push Button Actuators (Various button sizes available)

Toggle Actuator (momentary or constant contact)


Extension Leaf Actuator

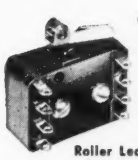

Special Push Button Actuator designed for fire control system

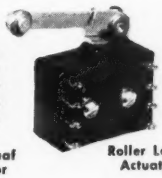


DOUBLE-POLE SIMULTANEOUS ACTION TYPE D-8

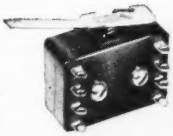
D.P.D.T., 4 Circuit 15 amps, 125/250 v. AC. 10 amps, 30 v. DC Ind. Eight terminals and four separate circuits which operate simultaneously permite switch to reverse 3-phase motors, replace expensive relays, etc.

Write for Data Sheet DU-11


Roller Leaf Actuator


Roller Lever Actuator

Leaf Actuator


Extension Leat Actuator

Push Button Actuators (Various button sizes available)

HERMETICALLY-SEALED DOUBLE-POLE SWITCH

Write for Data Sheet HJU-11

Type J2-4

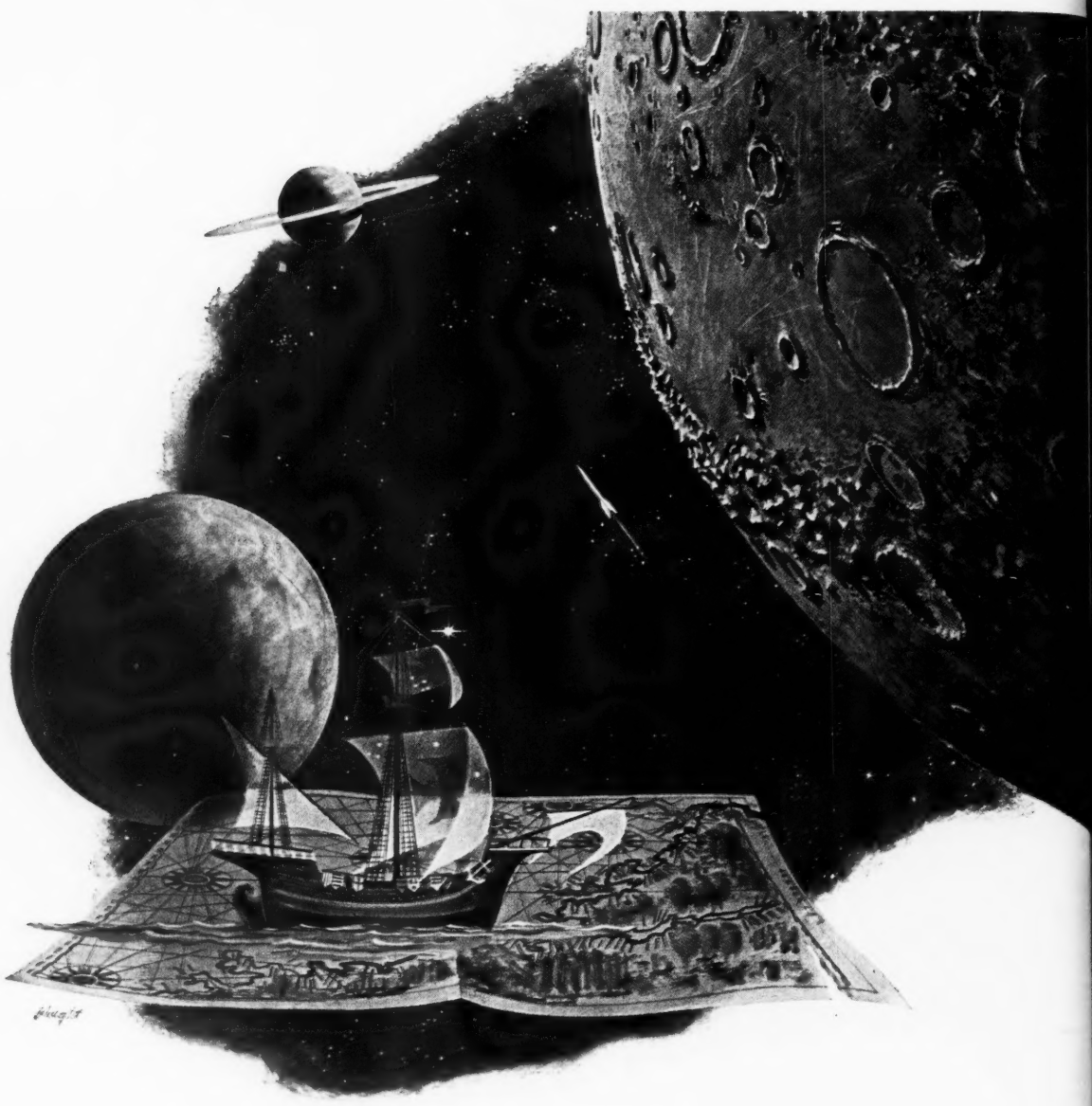
Toggle Actuator for J2-4

D.P.D.T., 4 circuit 10 amps, 125/250 v. AC/30 v. DC.

ELECTRO-SNAP SWITCH & MFG. CO. 4258 West Lake Street, Chicago 24, Illinois

MANUFACTURERS OF A COMPLETE LINE OF PRECISION SWITCHES FOR INDUSTRY AND AVIATION

ELECTRO SNAP



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CONVAIR-*Astronautics, is building a new facility at San Diego, California, which will be devoted to research, development, manufacturing and preliminary testing of the U.S. Air Force's Atlas Intercontinental Ballistic Missile, as well as other projects looking into the future of astronautics.*